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MATERIA MEDICA

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THERAPEUTICS

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MATERIA MEDICA

AND

THERAPEUTICS

INORGANIC SUBSTANCES

BY

CHARLES D. F. PHILLIPS, M.D.

MEMBER OF THE ROYAL COLLEGE OF PHYSICIANS, ETC.

LATE

LECTURER ON MATERIA MEDICA AND THERAPEUTICS AT THE WESTMINSTER HOSPITAL MEDICAL SCHOOL

London
J. AND A. CHURCHILL
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TO

JOHN ERIC ERICHSEN, F.R.S.,

EX-PRESIDENT OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND, SURGEON EXTRAORDINARY TO HER MAJESTY THE QUEEN,

THIS BOOK IS DEDICATED

AS AN

EXPRESSION OF ESTEEM FOR HIS PROFESSIONAL ABILITY,

AND OF

GRATITUDE FOR MUCH PERSONAL KINDNESS.

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PREFACE.

THIS volume is published in succession to one upon the Vegetable Kingdom, and is arranged upon a similar plan. Several of our best modern treatises upon the same subjects completely separate pharmacology from therapeutics, but it has seemed to me better to recommend their simultaneous study, and I have devoted more space than is now usual to pharmaceutical chemistry; this will be to the advantage, I am sure, of the student, and I trust, of the practitioner. That ample space should be given to discussing the physiological action of medicines is a necessary condition of any modern work, and if the conclusions reached, and the bearings of facts gathered under this head, are still rather vague and undefined, they at least engage and deserve earnest attention, and point to the direction in which further advance may be made.

My former volume was published in 1874, and as some explanation of the long interval between it and the present one, I may say that in 1877 I had commenced arrangements with the printer when a serious railway accident interrupted my work, and incapacitated me for any exertion for upwards of two years; the conditions under which I have now completed the book may perhaps be accepted as some apology for its defects.

During the interval, several excellent treatises on the same

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subjects have been published, and I have to acknowledge many obligations to those of Dr. H. C. Wood, jun., Dr. Bartholow, Dr. Garrod, Dr. Ringer, as well as to the works of Trousseau, Stillé, Husemann, Nothnagel, Köhler, Gubler, and Rabuteau. I am also indebted to the "Poisons" of Dr. Taylor, the "Therapeutics" of Dr. Waring, the "Commentary" of Dr. W. G. Smith, the "Handbook" of Dr. Fothergill, the "Companion" of Squire, and the "Chemistry" of Miller: the latter I have mainly followed as to mercury, iron, and other important drugs, but it is possible that some discrepancies may still be found between older and more modern chemical formulæ.

The "Medical Digest" of Dr. Neale I have found exceedingly useful. Various important monographs, *e.g.*, those of Preyer, Binz, Liebreich, Frazer, Brunton, and others, and valuable papers in various journals will be found quoted in their proper place.

The abbreviations and references will, I believe, be found sufficiently full for easy recognition. The British Medical Journal is quoted as B. M. J.; the British and Foreign Medico-Chirurgical Review either as Brit. and For. Rev. or as Med.-Chir. Rev.; the Edinburgh Journal of Medicine as Edin. Journ.; the American Journal of the Medical Sciences as Amer. Journ. or Amer. Rev.; "Practitioner" refers to the London journal of that name, unless otherwise specified; "Dub. Quart." or "Dub. Journ." to the Dublin Journal of Medical Science.

Finally, I have to thank Dr. Mackey, Dr. Menzies of Cannes, Dr. Port, and Mr. A. Pearce Gould, for their valuable assistance in looking up references and aiding me with many suggestions and corrections while the work was passing through the press.

2, Grosvenor Square, W.,
December 1, 1881.

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CONTENTS.

PAGE

OXYGEN—OZONE—COMPRESSED AIR .. .. 1—8
Physiological Action, External, 2—Internal, 2—9
Therapeutical Action, 10
Mode of Administration, 18

NITROGEN 19

HYDROGEN 20
Peroxide of, 21

CARBO—CHARCOAL 23
Therapeutical Action, External, 24—Internal, 25
Preparations and Dose, 26

SULPHUR 26

SULPHIDES OR SULPHURETS 28
Absorption and Elimination, 28
Physiological Action, External, 29—Internal, 30
Therapeutical Action, External, 32—Internal, 36
Preparations and Dose, 43
Adulteration, 44

PHOSPHORUS 45
Absorption and Elimination, 46
Physiological Action, External, 47—Internal, 48
Toxic Action, 51
Tolerance, 53
Theory of Action, 54
Antidotes, 57
Therapeutical Action, Internal, 59
Preparation and Dose, 73

IODUM—IODINE 75

Digitized by Google

PAGE

Compounds of Iodine—Iodoformum 76, 77
Absorption and Elimination, 77
Physiological Action, External, 80—Internal, 81
Idiosyncrasy—Toleration, 88
Incompatibles, 90
Therapeutical Action, External, 90—Internal, 106
Preparations and Dose, 120

Bromum—Bromine 121
Physiological Action, 122
Therapeutical Action, External, 123—Internal, 125

Compounds of Bromine 125
Absorption and Elimination, 126
Physiological Action, Internal, 128
"Bromism," 129
Therapeutical Action, External, 134—Internal, 135
Preparations and Dose, 153

Chlorum—Chlorine 154
Absorption and Elimination, 156
Physiological Action, External, 156—Internal, 157
Therapeutical Action, External, 158—Internal, 160
Preparations and Dose, 160

Aqua—Water 161
Absorption and Elimination, 161
Physiological Action, External (Forms of Bath), 161—Internal, 174
Therapeutical Action, External, 176—Internal, 192

Sea-Bathing 194
Physiological Action, 195
Therapeutical Action, 196
Errors in, 197

Mineral Waters and Baths 198
Physiological and Therapeutical Action, 198
Classification, 199

Acidum Aceticum—Acetic Acid—Glacial Acetic Acid 231

Acidum Aceticum Dilutum—Vinegar 232
Absorption and Elimination, 233
Physiological Action, 233
Preparations and Dose, 236

Digitized by Google

PAGE

ACIDUM CARBONICUM—CARBONIC ACID 236
Absorption and Elimination, 237
Physiological Action, 238
Therapeutical Action, 240

ACIDUM CITRICUM—CITRIC ACID 243
Absorption and Elimination, 244
Physiological Action, 244
Therapeutical Action, 245
Preparation and Dose, 245

ACIDUM HYDROCHLORICUM—HYDROCHLORIC ACID 246
Absorption and Elimination, 246
Physiological Action, 247
Toxic Action, 250
Therapeutical Action, External, 252—Internal, 253
Preparations and Dose, 256

ACIDUM NITRO-HYDROCHLORICUM DILUTUM—DILUTE NITRO-HYDROCHLORIC ACID 257
Physiological and Therapeutical Action, 257
Preparations and Dose, 259
Bath, 259

ACIDUM HYDROCYANICUM DILUTUM—DILUTE HYDROCYANIC ACID .. 260
Absorption and Elimination, 262
Physiological Action—Toxic Action, 263
Theory of Action, 269
Antidotes, 271
Therapeutical Action, External, 272—Internal, 273
Preparations and Dose, 276

ACIDUM NITRICUM NITRIC ACID 277
Absorption and Elimination, 278
Physiological Action, 278
Therapeutical Action, External, 279 - Internal, 282
Preparations and Dose, 285

ACIDUM PHOSPHORICUM DILUTUM—DILUTE PHOSPHORIC ACID .. 285
Absorption and Elimination, 286
Physiological Action, 286
Therapeutical Action, 289
Preparation and Dose, 292

Digitized by Google

PAGE

ACIDUM SULPHURICUM—SULPHURIC ACID 292
Absorption and Elimination, 293
Physiological Action, 294
Therapeutical Action, External, 297—Internal, 298
Preparations and Dose, 300

ACIDUM SULPHUROSUM—SULPHUROUS ACID 301

ALKALINE SULPHITES AND HYPOSULPHITES 302
Absorption and Elimination, 303
Physiological Action, External (Disinfection), 303—Internal, 305
Therapeutical Action, External, 306—Internal, 313
Preparations and Dose, 319

ACIDUM TARTARICUM—TARTARIC ACID 319
Absorption and Elimination, 320
Physiological Action, 320
Therapeutical Action, 321
Preparation and Dose, 322

AMMONIUM—AMMONIA 322

COMPOUNDS OF AMMONIA 323
Absorption and Elimination, 326
Physiological Action, 327
Therapeutical Action, External, 331—Internal 334
Preparations and Dose, 340

ALUMINIUM—ALUM 341

COMPOUNDS OF ALUMINA 342
Absorption and Elimination, 342
Physiological Action, 343
Theory of Action, 345
Therapeutical Action, External, 345—Internal, 350
Preparations and Dose, 354

ANTIMONIUM—ANTIMONY AND COMPOUNDS 355
Absorption and Elimination, 358
Physiological Action, External, 359—Internal, 360
Tolerance, 363
Theory of Action, 367
Antidotes, 370
Therapeutical Action, External, 370—Internal, 371
Preparations and Dose, 384

Digitized by Google

PAGE

ARGENTUM—SILVER 384

COMPOUNDS OF SILVER 385

Absorption and Elimination, 386
"Argyria," 387
Physiological Action, External, 389—Internal, 390
Therapeutical Action, External, 394 (Caustic, Astringent, Counter-irritant)—Internal, 406
Preparations and Dose, 414
Mode of Administration, 415

ARSENICUM—ARSENIC AND COMPOUNDS 416

Absorption and Elimination, 419
Physiological Action, External, 420—Internal, 422
Toxic Action, 435
Tolerance, 437
Arsenical Wall-papers, 439
Antidotes, 441
Therapeutical Action, External, 441—Internal, 443
Preparations and Dose, 473
Mode of Administration, 474

AURUM—GOLD AND COMPOUNDS 476

Absorption and Elimination, 477
Physiological Action, 478
Therapeutical Action, External, 479—Internal, 480
Preparations and Dose, 482

BARIUM—BARYTA 483

Absorption and Elimination, 483
Physiological Action, 484
Therapeutical Action, 485
Preparations and Dose, 486

BISMUTHUM—BISMUTH 486

COMPOUNDS OF BISMUTH 487

Absorption and Elimination, 488
Physiological Action, External, 489—Internal, 490
Therapeutical Action, External, 493—Internal, 495
Preparations and Dose, 499
Adulterations, 500

CADMIUM 502

Absorption and Elimination, 503
Physiological Action, 503
Therapeutical Action, 504
Preparations and Dose, 504

Digitized by Google

PAGE

CALCIUM—LIME 505

COMPOUNDS OF LIME 505

Absorption and Elimination, 509
Physiological Action, External, 511—Internal, 512
Lime in Potable Waters, 514
Goitre, 515
Therapeutical Action, External, 516—Internal, 520
Preparations and Dose, 530

CERIUM—OXALATE OF CERIUM 531

Physiological Action, 531
Therapeutical Action, 532
Preparation and Dose, 534

CUPRUM—COPPER 534

COMPOUNDS OF COPPER 535

Absorption and Elimination, 536
Physiological Action, External, 537—Internal, 538
Toxic Action, 539—"Cuprismus," 540—Antidotes, 543
Therapeutical Action, External, 543—Internal, 545
Preparations and Dose, 551

FERRUM—IRON 552

COMPOUNDS OF IRON 553

Absorption and Elimination, 560
Physiological Action, External, 566—Internal, 567
Different Action of Proto- and Per-salts, 572
Therapeutical Action, External and Internal, 575
Preparations and Dose, Mode of Administration, 615

HYDRARGYRUM—MERCURY 618

COMPOUNDS OF MERCURY. 619

Absorption and Elimination of Metallic Mercury, 624—of Calomel, 627—of Corrosive Sublimate, &c., 629
Physiological Action, External, 631—Internal, 632
"Mercurialism," 643—Antidotes, 647
Therapeutical Action, External, 647—Internal, 657
Preparations and Dose, 671
Inunction, 673
Hypodermic Use, 674
Vapour Bath, 675

LITHIUM 675

COMPOUNDS OF LITHIUM 676

Absorption and Elimination, 677
Physiological Action, Internal, 678
Therapeutical Action, External, 679—Internal, 680
Preparations and Dose, 682

Digitized by Google

PAGE

MAGNESIUM AND COMPOUNDS 683
Absorption and Elimination, 685
Physiological Action, 685
Theory of Purgative Action, 687
Therapeutical Action, 691
Preparations and Dose, 695

MANGANESIUM—MANGANESE AND COMPOUNDS 697
Absorption and Elimination, 698
Physiological Action, 698
Therapeutical Action, External, 700—Internal, 701
Preparations and Dose, 703

PLUMBUM—LEAD AND COMPOUNDS 704
Absorption and Elimination, 706
Physiological Action, External, 706—Internal, Toxic Action, 707
Plumbism, 708—Theories of, 711—Modes of, 714
Idiosyncrasy, 715
Therapeutical Action, External, 716—Internal, 719
Preparations and Dose, 721

POTASSIUM—KALIUM AND COMPOUNDS 722
Absorption and Elimination, 728
Physiological Action, Oxidation, 729
Therapeutical Action, External, 736—Internal, 741
Preparations and Dose, 751

SODIUM—NATRIUM 752
COMPOUNDS OF SODIUM 753
Absorption and Elimination, 757
Physiological Action, External, 758—Internal, 759
Therapeutical Action, External, 764—Internal, 767
Preparations and Dose, 773

STANNUM—TIN 774
Therapeutical Action, 775
Preparations and Dose, 775

ZINCUM—ZINC AND COMPOUNDS 776
Absorption and Elimination, 778
Physiological Action, External, 778—Internal, 779
Therapeutical Action, External, 781—Internal, 784
Preparations and Dose, 787

INDEX OF REMEDIES 789
INDEX OF DISEASES 799

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MATERIA MEDICA

AND

THERAPEUTICS.

INORGANIC SUBSTANCES.

OXYGEN, O, = 16—OZONE, O_3.

OXYGEN is the most universally diffused element, forming part of the air, the water, the earth, and of the tissues of plants and animals. Of the air it constitutes 23·01 per cent. by weight, 20·81 per cent. by measure, being about one-fifth part. By Priestley, who discovered it (in 1774), it was named "dephlogisticated, or vital air."

OZONE is an allotropic form of oxygen. Its discoverer, Schönbein, did not arrive at a knowledge of its real nature, but Odling (in 1860), by a "splendid hypothesis," concluded it to be a *condensed* condition of oxygen, and this was afterwards verified, amongst other observers, by Brodie, who adopted the symbol O_3, implying that *three* atoms of oxygen are condensed in each *one* of ozone. A minute proportion of it is found in the atmosphere—more in that of the open country and of the sea than in that of towns, but its precise distribution and variation are not yet ascertained. Richardson calculated its amount as 1 in 10,000 of air (Brit. Assoc. Rep., 1865).

PREPARATION.—Oxygen may be obtained pure from most of its combinations, but is conveniently and usually prepared

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by heating the peroxide of manganese, or the chlorate of potash, or both together. The former yields about one-ninth of its weight of oxygen. $3MnO_2 = MnO, Mn_2O_3 + 2O$; or $2KClO_3 = 2KCl + 3O_2$.

Ozone is produced in small quantities during the slow oxidation of phosphorus and some other substances. Lender recommends for its evolution in sick chambers, a mixture of peroxide of manganese, permanganate of potash, and oxalic acid, to be dissolved in water. In the laboratory it is prepared by passing a succession of electric sparks through a closed chamber filled with air.

CHARACTERS AND TESTS.—The principal characteristic of oxygen is its energetic power of combination with organic principles, and with minerals, to form acids and salts (oxidation), and with hydrogen to form water. It is a gas devoid of colour, odour, or taste, of sp. gr. 1·1057 (atmospheric air being taken as 1). Under a pressure of 320 atmospheres, and at a temperature of −220° F., it has been liquefied by Pictet (1877).

Ozone is much denser than oxygen, and in most chemical and physical, though not in all vital effects, it is more active: it is further distinguished by a peculiar odour: also it is a powerful oxidizing agent, and changes many protosalts into persalts: it displaces iodine from some of its combinations, hence iodized starch paper is used as a test for the gas—the paper turns bluish as iodine is set free and combines with the starch, but the test is not very dependable. Ozone is absorbed by turpentine.

According to Paul Bert, it possesses marked antiseptic properties, and animal substances keep long unputrefied in an atmosphere to which a minute proportion of ozone has been added (Med. Record, 1876; Comptes Rendues, t. 80).

PHYSIOLOGICAL ACTION.—*External.*—The external and local action of oxygen in contact with mucous membrane or denuded skin is moderately stimulating.

PHYSIOLOGICAL ACTION.—*Internal.*—To describe fully the physiological action of oxygen would involve a description of the processes of respiration, sanguification, nutrition, and tissue-change, for to all these, and to life itself, it is essential. If it be

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deficient in the respired air, or if it be insufficiently absorbed, all the functions become disordered, assimilation is impeded, circulation diminished, and temperature lowered, and if its access to the lungs be prevented for a few minutes, life altogether ceases. But we are concerned, at present, only with the results of certain experiments in which animals or men have been made to respire either pure oxygen, or an atmosphere artificially charged with a definite proportion of the gas, and the first question that arises is whether more than a normal amount of oxygen can be taken into the blood under such circumstances.

It was early proved that animals kept under a bell-jar filled with oxygen lived longer than in ordinary air; and also that animals made to breathe oxygen could resist asphyxia longer than similar animals that had breathed only air (Priestley, Beddoes), but Regnault and Reiset, whilst corroborating the former observation, concluded from a series of experiments that breathing an atmosphere rich in oxygen, or even one of the pure gas, did *not* make the blood take up more oxygen than it would from ordinary air, nor was more carbonic acid excreted in consequence (Annales de Chimie, 1844). But these conclusions, which had much influence on professional opinion at the time, have been disproved. Preyer showed that a greater saturation from oxygen-inhalation is, *à priori*, probable, and that ordinary arterial blood is not fully saturated with oxygen—that it can take up more by being shaken with the gas. Demarquay proved it by showing that suppurating, indolent, or unhealthy wounds on the extremities of animals became quickly florid and hyperæmic when pure oxygen was inhaled—an extra amount of the stimulating gas must clearly have been carried by the circulation to the wound. Allen and Pepys, and later, Limousin, showed, by inhaling an equal quantity of atmospheric air at one time, and of oxygen at another, that after the latter, double the amount of carbonic acid was expired, and this increase continued fifteen minutes after the inhalation had finished. Other observers have reported that the elimination of uric acid during a course of oxygen-inhalation is markedly lessened, *i.e.*, that more complete combustion occurs within the system (Schmidt's Jahrb., 1865, t. 1, s. 28); thus Kollmann found that whilst 300 grammes of the

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ordinary secretion of urine contained 236 milligrammes of acid, the same quantity contained only 122 milligrammes after inhalation of 12 litres of oxygen. On another occasion the amount of acid came down from 134 milligrammes to 25 milligrammes.

A clinical illustration, pointing in the same direction, is given by Gubler. After several copious draughts of the pure gas in an active nascent condition, the respiratory movements and the pulse became slower, a general sense of comfort was felt, and without any dyspnœa, the pause between expiration and inspiration could be much prolonged. Thus, taking 30 seconds as a maximum time during which the breath may be "held" after breathing atmospheric air, it rises to 90 to 100 seconds after breathing oxygen. From other observations, Gubler concludes that the blood receives the gas in proportion to its physical capacity for it, rather than in proportion merely to the vital necessity of hæmatosis: the globules absorb what they need, whilst any excess circulates free, and enters into combination only as the hæmoglobulin loses oxygen in passing through the capillaries. Hence the amount of oxygen absorbed by an individual is proportionate to the number of his corpuscles (we should now say of his hæmoglobin), and a plethoric man using quickly up his reserve air breathes faster than a healthy one. On the other hand, an anæmic patient also breathes more rapidly than normal, since his corpuscles are either too few in number or otherwise altered, so that they cannot take up enough oxygen.[1] Buchheim states an opposite view, viz., that oxygen is not absorbed proportionally to the amount of it brought to the lungs, but to its requirement for tissue-change—yet even he admits that the amount taken in can be increased to some extent by continued deep inspirations, and by breathing air rich in oxygen or under high pressure; he only denies that such adventitious oxygen affects the tissue-change (Archiv f.

[1] "Quinquaud, availing himself of the reducing properties of sodic hydrosulphite, was enabled to calculate the maximum quantity of oxygen capable of being absorbed by a given amount of blood. The mean capacity in health, he found, was 240 cubic centimètres of oxygen to every 1,000 grammes of blood = 128 grammes hæmoglobin." He assumes that this absorption capacity is invariable, but in reality it varies according to illness, especially in forms of anæmia (Coupland, Gulstonian Lectures, March, 1881).

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Exper. Pathol. Klebs, Bd. iv., 1875)—he admits also that improvement in symptoms may result from breathing compressed air or pure oxygen, but thinks we cannot hope to influence the course of illness by increasing the amount of oxygen contained in the blood.

Granting, then, the possibility of taking into the blood more than the normal amount of the gas, yet it remains true that in many *healthy* persons no marked effect is to be noted from inhalations of 15 to 30 litres of oxygen, unless it be a sense of warmth in the mouth and at the epigastrium (Husemann).

Naoumoff and Beliaieff, breathing it for 7 to 17 minutes, found no appreciable change in pulse or temperature, whilst in dogs made to breathe alternately air and oxygen, the temperature rose sometimes with the latter a few tenths of a degree, and there seemed some dilatation of capillaries (Abstract, Lancet, i., 1875).

Mr. Savory, partly following Regnault and Reiset, and partly relying upon observations with animals which showed no increase of temperature under oxygen-inhalations, has also argued that these can exert no effect on the system; but Dr. Edward Smith has pointed out that such experiments, to be conclusive, should extend over long periods, and take account of changes in diet, etc.—he himself found evidence of increased chemical change under oxygen.

In some persons, inhalation of the gas causes temporary nerve-symptoms, such as exhilaration, sense of vigour, heat of skin, tingling of fingers, and even pain referred to the fifth nerve (Husemann). I have myself observed all these symptoms, except the last, immediately after the inhalation; also some giddiness, and some rise of pulse, probably from extra effort in breathing; in the delicate, improved appetite, improved motor power, and sleep have followed. I can corroborate this observation, which has been made by Birch, Demarquay, and others. Oxygen, then, is not without effects, though these vary with different individuals, and we cannot yet reduce them to precise scientific expression.

Dr. Richardson, judging partly from a case in which the blood passed from the lungs back to the right heart, and so circulated "surcharged with oxygen," states that such excess leads to great exhaustion of muscular and nerve-power and

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constant perspiration (Lancet, ii., 1878), but the conditions are not simple enough for asserting that these symptoms are solely due to the gas. If an animal be kept in a closed vessel full of oxygen it dies, we cannot exactly say why. Broughton discovered that rabbits, guinea-pigs, sparrows, etc., thus kept, were at first lively and excited with quickened circulation and respiration, but passed in an hour's time into a weakly depressed condition, and finally died, although the air in the bell-jar was still pure enough to rekindle a flame. Dr. Richardson obtained similar results with oxygen that had been breathed and then purified, and he inferred that some principle essential to life was removed from the gas in the process of respiration (B. M. J., ii., 1860). He found in the animals after death a condition of "hyperinosis," and Demarquay, who met with analogous results, describes the volume of the blood as apparently much increased, the muscular and other tissues brightly red, the venous blood distinctly to be recognized, but less dark than usual, and more quickly reddened on exposure, the lungs congested being "intensely red," and all the viscera unduly vascular. The same observer states that a small amount of the gas may be passed directly into the blood by careful intravenous injection, and in such cases, after death, the spleen is markedly redder than usual.

Theory of Action.—Rosenthal concluded from certain experiments that an increased amount of oxygen in the blood caused "apnœa," for if, after blowing in air for 20 to 60 minutes through the trachea of an animal, the artificial respiration be suddenly interrupted, the animal remains motionless and without breathing for 20 to 40 seconds, then respiratory action, at first weak, ultimately normal, returns. Now this being an opposite condition to one of *dyspnœa*, and the latter being dependent upon *want* of oxygen and consequent extra stimulus of the respiratory centre, he argued that apnœa must depend on overmuch oxygen. Ewald also, by experiment, determined some slight increase of oxygen in the blood in apnœa; Hering not so. In any case there is really no causal relation between the two facts (Buchheim, loc. cit.), nor is apnœa complained of after oxygen-inhalation or condensed air treatment.

Experiments of this nature, though very interesting, cannot be taken as practical guides in the clinical use of the gas, and

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under ordinary conditions of inhalation oxygen never causes the lung-inflammation and exaggerated vital processes predicted by Beddoes and others.

Direct Influence of Oxygen on the Heart.—Some observations by Cyon on this subject deserve notice. Separating the heart of a frog, he connected it with a system of glass tubes and a manometer, and then passed through its cavities first serum saturated with carbonic acid gas, and afterwards serum saturated with oxygen. The former caused sudden arrest in diastole, whilst the latter restored the movements of the heart. Mr. Erichsen found, in experiments on asphyxiated animals, that ventricular contraction could be re-excited by oxygen when ordinary air had no effect. According to Hermann oxygen is not indispensable for the cardiac contractions, they may occur without it, but irregularly; and if the gas be absent, or supplied in insufficient quantity, regular and synchronous contractions are impossible (Robin's Journ. d'Anat. et de Physiol., 1868–70).

Musculo-Nervous System.—Many observers have localized in the muscular system the special action of oxygen, and Spallanzani, finding that a chrysalis absorbed much less of the gas than a butterfly, argued that the difference was determined by the less movement of the former. Brown-Séquard has shown, by interesting experiments, that when the muscular and the nerve-tissues have lost their vital properties, they may recover them under the influence of freshly oxygenated blood (Journal, 1858). Thus, having injected some of his own blood (defibrinated and charged with oxygen) into the radial artery of a man executed thirteen hours previously, and whose limbs were quite rigid, muscular irritability returned to the hand. In another case he removed the arm, and three hours later, when rigor mortis was complete, he injected dog's blood through the brachial artery, and the rigidity disappeared, first in the fingers, then in other parts; the skin resumed its colour, became elastic and supple, and the hair-bulbs projected (goose-flesh). In animals the vital qualities could not be restored so long after death; but in one curious experiment, the head of a dog being cut off, was injected through the carotid and vertebral arteries, and movements of the eyes and the face-muscles

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continued for a quarter of an hour. Other observations have proved that oxygen augments the vital functions of the spinal cord and motor and sensory nerves, and that, by the continued injection of blood charged with it, a dead body resists decomposition for upwards of fifty hours. Richardson, injecting oxygen into the arteries of recently killed animals, tested the muscular irritability by Faradaic currents, and found that the gas (warmed to 75° F.) increased irritability very much, but only for a short time. The onset of permanent rigidity was rather hastened.

COMPRESSED AIR.—PHYSIOLOGICAL ACTION.—This varies somewhat according as to whether the patient is wholly immersed in an atmosphere of air compressed to ½ to 1 atmosphere in a closed chamber for one or two hours, or whether he simply breathes it from a reservoir through a tube with closely-fitting mouthpiece for 20 to 60 inspirations.

The former and older method, as carried out at Reichenhall, often caused oppression of head, tinnitus, and other disagreeable sensations, but had a sedative and equalizing effect on the circulation, slowing heart-action, raising arterial tension and altering the distribution of blood, lessening its amount in the veins and increasing it in the arteries. It increased also expectoration and excretion (Burdon Sanderson, Practitioner, vol. i.).

In the more recent method employed by Waldenburg and Biedert, the extra compression amounts to only $\frac{1}{100}$ to $\frac{1}{15}$ atmosphere, and the good results obtained are more clearly traceable to the extra amount of oxygen. Nutrition and blood-formation are improved, the "lesser circulation" is rendered freer and less congested, and at the same time the vital capacity of the lungs is increased. The alternate use of *rarefied* air, which induces rather opposite conditions, is employed in this method (Med. Times, ii., 1877). Certainly theory favours further trials of "pneumatic medicine," but we require more extensive experience before judging of its merits. Ducrocq, indeed, reports almost opposite conclusions to those of Burdon Sanderson (Archives Gén., Sept., 1876).

Mosso describes various anomalous results in the distribution of blood in the extremities under a pressure of 2 atmospheres,

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and explains them by changes in the innervation of the heart, or with Paul Bert by chemical, rather than by mechanical changes (Med. Record, 1879).

Workmen employed in making bridges, etc., under a pressure of 2 to 3 atmospheres, suffer from pains in the ears and joints, apparently due to "dilatation of superficial vessels," after leaving work. Amongst a large number of men no hæmorrhage, heart disease, or serious disorder occurred (Med. Times, ii., 1877; *cf.* Moxon, B. M. J., i., 1881, p. 496).

OZONE.—PHYSIOLOGICAL ACTION.—Dewar and McKendrick pointed out the remarkable fact that, instead of the blood becoming more highly oxygenated under ozone-inhalations, it assumes venous characters in all the vessels, a fact which is explained by the greater density of this gas interfering with the due excretion of carbonic acid from the blood; it causes also some local irritation of the lining of the air-passages, and it induces slowing of the heart-action and respiration (Proc. Roy. Soc., 1873–74).

This was not in accord with previous observations, for Dr. Ireland had stated that ozone *quickened* respiration and circulation, excited the nervous system, and promoted coagulation of blood (Edin. Med. Journ., 1862–63, p. 729), but it is probable that his animals respired mainly oxygen. Day also had found that oxygen, "ozonized in proportion of one-twelfth, caused rapid respiration and heart-action, and much local irritation;" but quite recently, Dr. John Barlow has confirmed and added to the observations of Dewar and McKendrick. He reports that ozonized air depresses the nervous system, probably through leading to accumulation of carbonic acid in the blood; it lessens the frequency of respiration, and hence also of heart-action, together with the excretion of carbonic acid and the absorption of oxygen. It irritates the pulmonary mucous membrane, and may cause bronchitis or lung-congestion (Redfern), or even asphyxia. It decolorizes the red corpuscles, and causes a granular appearance, probably from uniting with hæmoglobin; it stops the amœboid movements of the white corpuscles, and renders the nucleus apparent; there is no evidence of its entering the circulation in a free state.

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As illustrating its irritant effect, Dr. Barlow records its producing an obstinate inflammation of the nasal membrane (Journ. Anat., Oct., 1879).

THERAPEUTICAL ACTION.—*External.* — Ulceration — Gangrene.—The gas has been applied in jet to atonic scrofulous ulcers by M. Demarquay, with much advantage.

Gangrene has been attributed by M. Raynaud to deficient oxygenation of tissue, and Langier and other French surgeons have recorded good results from its local treatment by oxygen (Bulletin de Thérap., 1863-66). The destruction of tissue has been checked and limited, the swelling subdued, and the neighbouring threatened livid tissue restored to its natural colour. Dr. Goolden has recorded severe cases of phagedænic ulceration, especially one affecting the throat, which yielded to local application of oxygen, and he has recently written to renew his advocacy of this remedy (Lancet, i., 1866, ii., 1879).

THERAPEUTICAL ACTION. — *Internal.* — Inhalation. — Remedially, oxygen may be considered as it exists diluted in the atmosphere, or as prepared artificially for inhalation with a definite proportion of air.

Pure fresh air of the elevated country or the coast is of well-known efficacy in all conditions of debility, of chronic catarrh and chronic dyspepsia; sea air especially contains more ozone than the air of land, and is of value to those who have lived in towns, and followed sedentary occupations. On the other hand, patients with weak chests and readily congested lungs are better in a less rare and less ozonized atmosphere, since a large proportion of ozone may excite in them irritation of mucous membrane (Cornelius Fox). During epidemics of influenza an unusual amount of ozone has been verified in the air, whilst in cholera epidemics it has been almost absent. The choice of a climate for any given case is, however, generally influenced by other considerations than the mere amount of oxygen to be obtained; the subject need not, therefore, be fully considered in this place. The chief cases in which theory indicates, and experience justifies, the use of oxygen-inhalation, are those of asphyxia and of venous congestion occurring in the course of phthisis, asthma, or emphysema.

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Asphyxia.—When this condition is induced by breathing noxious gases, the best results are obtained from oxygen. Sometimes a free current of fresh air is sufficient to restore persons rendered unconscious by an escape of gas or by the products of combustion retained within a room; but in extreme cases, pure oxygen would seem the only means of saving life. Limousin has reported a case of asphyxia from carbonic acid inhalation, with intense cyanosis, which recovered under the use of oxygen, and in which he was able to verify a steadily increased elimination of carbonic acid by the lung, in proportion to the oxygen taken (Compt. Rend. Soc. de Thérap., 1868). M. Constantin Paul has recorded many cases, including cyanosis from obstructed respiration, coma from opium-poisoning (when the respirations were only seven per minute), and asphyxia from carbonic oxide, all quickly and markedly relieved by oxygen (Bulletin de Thérap., Aug., 1868). Rabuteau refers to an instance of its good effect in asphyxia from sewer-gas, when ordinary means, employed by M. Grisolle, had failed to relieve (Élements, p. 48); and finally I may quote a striking case recently reported by Dr. Charles B. Ball. A man, wife, and daughter were found unconscious in a small room where there had been, through the night, a large fire, though the chimney was blocked. The two adults recovered with fresh air and ordinary means, but the daughter, aged sixteen (phthisical), remained unconscious and convulsed. After many hours of stimulating treatment she seemed to be dying—respiration was feeble and slow, the pulse imperceptible—then she was made to inhale pure oxygen, afterwards oxygen and air. "The effects were rapid and marked," respiration, colour, and pulse improved, and though at first convulsed, she ultimately recovered. Dr. Ball, impressed by this case, and remembering Reynault's proof that man can live in an atmosphere strong in carbonic acid, provided that the proportion of oxygen is also increased, has contrived an apparatus with a reservoir of oxygen and a mask for safe use in dangerous mines. He has himself safely respired an atmosphere containing 18 per cent. carbonic acid with 30 per cent. oxygen added (B. M. J., i., 1878). If we compare the result in Dr. Ball's case with the fatal course of such cases of gas-asphyxia as, *e.g.*, may be found in the Edinburgh Journal, 1874, we shall better realize the

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importance of using oxygen in preference to other measures. In various forms of poisoning whenever death threatens from asphyxia, as under prussic acid, chloroform, etc., artificial respiration, *i.e.*, supplying more oxygen, offers the best means of saving life.

Rosenthal and Leube found that the symptoms of strychnia-poisoning might be deferred or prevented by artificial respiration (Reichert's Archiv, 1867). H. Ebner thought the same result could be obtained by rhythmical movements of the limbs without supplying more air to the lungs, but Ananoff has since proved that pure oxygen is distinctly antagonistic to strychnia-action, and that when supplied to animals poisoned by this alkaloid it relieves them more than free access of ordinary air, or any movements (Centralblatt f. Med., No. 27, 1874).

Asthma — Emphysema, etc. — The main suffering, the "besoin de respirer," common to these maladies, is clearly traceable to deficient access of oxygen to the blood in the lung-capillaries, and I am satisfied that in the majority of instances relief to this suffering may be given by supplying a larger proportion of the gas. If it be objected that permanent good results are not obtained from it, the same objection may be made to many other remedies—it is still something to have a means at hand for temporary relief. Dr. John Hooper thus describes its effects in a man of fifty-five, "for many years a martyr to asthma." During a very severe paroxysm he was thought to be dying; it seemed impossible that he could rally. As a *dernier ressort*, oxygen was tried, the end of a glass retort containing it being applied to his mouth, though he had not power to enclose it with his lips. "The effect was wonderful and quickly manifest in increased mobility of the ribs, fuller inspiration, disappearance of lividity, and lastly in his seizing the end of the retort, and in the avidity with which he inhaled when possessing the voluntary power" (B. M. J., i., 1862). Details of diagnosis are not given in this instance, but paroxysms of true nervous asthma and of bronchitic asthma may both be shortened by similar inhalation. Beddoes related twenty-two cases, of which he claimed to have cured ten and relieved nine; and it seems worth while to refer to his case of "Mr. Hare, of Conduit Street, who, in 1796, after having been subject for eleven years to asthmatic attacks accompanied by indescribable suffering,

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and only relieved after many hours by blisters and expectorants," recovered average health under the use of the gas, continued for some months (op. cit., 4th part, p. 49). M. Demarquay also witnessed excellent results, *e.g.*, in a man aged nineteen, subject from childhood to asthmatic attacks—"they ceased, as if by magic, as soon as he began to inhale oxygen" (Essai de Pneumatologie, p. 725).

Dr. Mackey has reported a good illustration of the value of the gas in advanced emphysema pulmonum (Practitioner, vol. ii., May, 1869). A lady, aged fifty-five, was subject to constant dyspnœa, increased by every movement, and amounting at times to partial asphyxia. She had the physical signs of the malady, together with dilated weak heart and embarrassed circulation, as evidenced by œdema of the face and extremities; was subject to attacks of bronchitis, but at the time of treatment the main complaint was the difficulty of breathing. She inhaled a mixture of from three to twelve pints of oxygen, with sixty of air, at intervals of three or four days for a period of six weeks. After each dose "marked relief was experienced, which she expressed as being able to take a deep breath and get sufficient air (a feeling not known for years), as being able to move with comparative ease, feeling more buoyant and more like healthy persons should feel than she ever remembered." Expectoration was rendered more copious and facile for a day or two after the inhalation; there was no other definite effect on secretion, nor any on circulation, unless it were some palpitation during the night after a large dose. The nervous irritable states to which such patients are liable were also soothed under the treatment, which certainly effected more than ordinary medicinal agents. It could not, however, alter the organic conditions, and cardiac death occurred suddenly, after an attack of bronchitis, in the following winter.

These illustrations seem to me sufficient to prove that oxygen might be used more often than it commonly is in such cases. According to Biedert's method, emphysema is treated by a few short sittings of respiration in *compressed air*, and then by expirations into an atmosphere of *rarefied air*, "in order to counteract anæmia by attracting blood towards the lung-tissue."

In **Bronchitis**, bronchial catarrh, and bronchial asthma,

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compressed air is used to stimulate the lung, improve its circulation, and facilitate expectoration—it seems to be useless during actual asthmatic attacks. In mitral disease it is said to be valuable, and in dyspnœa dependent on dilatation of right heart.

Pleuritic Effusion—Empyema.—I have used oxygen in several of these cases with good results. During inhalation relief to breathing was experienced, which lasted for some time afterwards: compressed air has also been employed for these disorders. Biedert reports two cases of pleuritic adhesion in which vital capacity was much increased by it, and Kelemen one of empyema in which the effusion disappeared as diuresis set in. (Med. Record, Aug., 1879).

Whooping-Cough.—Moutard-Martin says that compressed air baths are efficient in this complaint (Union Med., March 11th, 1879).

Phthisis.—The true value of oxygen-inhalations in this disease has been the subject of much discussion. So early as 1783 it was tried with apparent good result, and Fourcroy was appointed by the French government to report on the subject. After examining into twenty cases he concluded that almost all patients benefited, for a time at least, by the treatment, but relapsed and got worse more rapidly and with more inflammatory complication than if oxygen had not been used (Sur les Proprietés Médicinales de l'Air Vital, 1789).

It is evident that to establish such a conclusion very careful observation is required, and more precision than the then art of diagnosis could attain, but the opinion exercised considerable influence at the time, was adopted by Dr. Beddoes and some other observers, and was one reason why this method of treatment fell into a disuse which was not altogether deserved.

Amongst modern writers, Dr. Birch, Constantin Paul, and Demarquay have reported relief in cases of phthisis, and the following occur amongst others related by Dr. Mackey. Mrs. W., aged thirty-one, of phthisical family, when first seen had had, for six months, cough, emaciation, and latterly diarrhœa, night-sweating, hectic, hæmoptysis, and purulent expectoration; much chest-pain; there were dulness and crepitation at left apex. After some months of treatment of the usual recognized kind, she improved, and complained mostly of

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debility, cough, pain, expectoration, and dyspnœa. She commenced oxygen-inhalations (six to twelve pints in sixty). After eight inhalations, at intervals of two days, all these symptoms were markedly better, and treatment was omitted. The malady was arrested for a time, but after exposure to poverty and misfortune, this patient died one or two years later.

R., aged nineteen, with family history of phthisis, after partial recovery from acute softening of the right apex, commenced inhalation as a remedy for dyspnœa and pain in the chest, and at the end of two months was sufficiently recovered to resume the sedentary work of a clerk. It should be stated that iron and cod-liver oil were given throughout, but the patient distinguished definite relief to his breathing from the use of the gas. He was in fair health six months afterwards, when the case was reported, but he died within eighteen months of acute phthisis, following imprudent exposure.

A third patient, a man of thirty-four, commenced inhalation whilst still suffering from acute symptoms dependent on softening tubercle, and continued it for nearly three months, with marked improvement as to breathing power, cough, expectoration, and appetite. In this case the end came by pneumonia and pleuritic effusion, but after a prolonged exposure to bad weather, and independently of the treatment.

Such cases in themselves do not show more than a temporary relief of symptoms, and at least no harm from the gas, and they are really too few for any conclusions. A larger number are given by Dr. A. H. Smith (New York Prize Essay), and his general results are so far favourable as to warrant still further trials with this agent. I would except from its use cases of very acute character, and of hæmoptysis, in which, indeed, the mere exertion of inhaling would contra-indicate it. In other cases benefit may be hoped for, not so much through any local action on the lung-tissue as through improvement of the blood-condition, the appetite, and the power of assimilation; nor, speaking from experience, do I believe that oxygen, used with ordinary care, and in such dilution as has been mentioned, can at all irritate or inflame the lung-tissue.

Dr. Read (Long Island) has reported a series of twenty cases treated by inhalations of oxygen in *conjunction* with cod-liver

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oil. The majority did well, and he reports it "an admirable adjuvant to the usual routine treatment of phthisis, especially when the patients were unable to go out of doors." He gave the gas also in acute pneumonia, and apparently with advantage. The use of compressed and rarefied air seems rather to alleviate symptoms than to cure phthisis. In pre-tubercular stages it may serve to strengthen the respiratory muscles and open out the chest, but it is not suitable for acute or hæmorrhagic cases, or those with a large area of congestion.

Hepatic Congestion.—Dr. Birch has advocated the use of the gas in this condition, and states that it will relieve the constipation and other symptoms connected with it. The remedy has no doubt been of service, especially in cases with much headache, depression, loss of appetite, and sense of pain and constriction about the shoulder and chest, with palpitation and dyspnœa. In some chronic cases in which it was tried I have not seen benefit, and, as a general rule, medicinal and dietetic treatment, with such oxygen as is obtained by increased *exercise*, will give at least more rapid results.

Chlorosis—Anæmia.—Beddoes relates many instances of chlorosis benefited by inhalations, but other observers have not met with equal success from its use in this malady. I have, however, known it relieve chlorotic headache. In extreme cases of anæmia, the gas is not always well borne—it has seemed sometimes to increase depression for the time, and cause faintness and palpitation.

Diabetes.—Pettenkofer and Vogt determined that diabetics absorbed less oxygen than healthy persons, and that hence we might hope, by introducing more into their system, to obviate some conditions of their malady.

Bouchardat, and also Demarquay, have recorded cases relieved by this treatment, but no extensive trial of it has been made. Peroxide of hydrogen has been given internally with the same object—of oxygenation—and with some partial success.

I have tried oxygen-inhalation in several cases of diabetes in which prostration, dyspnœa, and tendency to cyanosis were prominent symptoms—one case was at the very unusual age of seventeen months, another at thirteen years, and three others at adult age. The gas certainly relieved for a time the symptoms

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mentioned, although it did not in any instance reduce the sugar in the urine.

Albuminuria.—In a few cases of Bright's disease narrated by Dr. C. Paul, albumen disappeared from the urine during treatment by oxygen. This occurred also in the often quoted case observed by Kollman and Eckart (Schmidt-Jahrb., 1865). More recently, Dujardin Beaumetz reports a case "in the last stage," and in which every diuretic had proved useless, and yet, twenty-four hours after inhaling oxygen, the albumen disappeared, and was still absent twelve days afterwards when the case was reported (Med. Record, March, 1879). Other physicians, whilst recording similar cases in their own experience, stated that the good result was not of long duration.

Nerve-Disorders.—A few cases of severe neuralgia relieved by oxygen are on record (Birch, J. Hooper, loc. cit.), and it has been praised in spinal palsy, nerve-debility, and hysteria, but I think without sufficient reason. What little trial I have made of it in such cases has not given me any good result.

Dr. Ramskill has reported a case of epilepsy apparently relieved by the gas, which he gave by inhalation from peroxide of hydrogen (Med. Times, i., 1863).

Hydrophobia.—Drs. Paul and Josias used oxygen in this malady, and although the patients died, some relief was given to the symptoms of asphyxia. Recently Dr. Schmidt has recorded the case of a girl, aged twelve, who, when recovering from diphtheria, was bitten by a mad dog; seventeen days afterwards she had difficulty of breathing and of swallowing, and oxygen-inhalation relieved her: she relapsed next day with convulsions, spasms of respiratory muscles, and unconsciousness; oxygen again relieved her, and after some complications traceable to the diphtheria, she ultimately recovered (Med. Record, 1878).

Tetanus—Strychnia-Poisoning.—Richardson refers to some cases of tetanus, under Sir J. Paget, much relieved by oxygen-inhalation: the patients became bathed in perspiration, and the muscles relaxed. He insists also on its importance in strychnia-poisoning in conjunction with amyl nitrite: as unless elimination be promoted by oxygen the spasm, even if relieved, soon returns. "Oxygen is a remedy for all excess of nerve-action leading to spasm" (*cf.* p. 12).

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MODE OF ADMINISTRATION.—M. Demarquay obtained his oxygen from chlorate of potash and made use of caoutchouc bags, which were filled with the washed gas, and could be carried to the patient's bedside. M. Limousin has introduced a small portable apparatus with brass retort, wash-bottle, and caoutchouc bag, so that the gas can be prepared and used on the spot: but in this country, the most available method is that of Mr. Barth, of Bloomsbury; he supplies a small gasometer, with the gas condensed under high pressure into iron bottles from which a measured quantity can be introduced, and mixed in definite proportion with air, and then inhaled in the usual way. This method leaves nothing to be desired. The patient should be quiet for a time before and after inhalations, and not be over-fatigued. The stomach should be neither full nor quite empty; the feet should be warm, and the circulation equable. Other modes have been devised for introducing oxygen into the system, as by oxygenated water and oxygenated bread, but I have no confidence in these preparations. A method still open to investigation is the administration of peroxides, especially those of hydrogen and of iron, and of chlorate or permanganate of potash (*v.* Potash); and some experiments of C. Bernard warrant the conclusion that these compounds give up to the blood a proportion of their oxygen, and are eliminated in a less oxidized condition.

CONTRA-INDICATIONS.—I have not met with any case wherein oxygen, more or less diluted, was indicated, and could not be safely used. If organic heart-disease be present, care should be taken to regulate the force and the effort of inhaling, which sometimes gives rise to giddiness or palpitation independent of the remedy. Some soreness of the throat, and temporary discomfort about the mouth, may occur if the apparatus be not quite free from dust, but from the gas I have seen no bad results whatever. The contra-indications to the use of compressed air are degeneration of vessels and an apoplectic tendency: to that of rarefied air, pulmonary hæmorrhage.

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NITROGEN, N, = 14.

This gas is very widely diffused, constituting 76·99 per cent. by weight of the atmosphere, 79·19 per cent. by measure. In combination, it occurs in the mineral kingdom as the basis of nitrates, nitrites, etc., it enters into the composition of almost all *animal* tissues, and in the vegetable kingdom it is found as a constituent of the alkaloids and the most active medicines, as well as of the most nourishing foods.

PREPARATION.—Nitrogen may be obtained by burning either phosphorus or a mixture of iron filings and sulphur, or certain other substances, in a limited quantity of air, as under a bell-jar: the oxygen will be taken up and only nitrogen left. The process is not an easy one, and hence, possibly, the little trial so far made of the gas in medicine.

CHARACTERS.—A colourless, odourless gas, sp. gr. ·975, soluble in water to some extent.

PHYSIOLOGICAL ACTION.—This is negative in character; the gas will not support respiration ("azote") nor combustion, and it seems to act in the atmosphere as a diluting agent for the too stimulating oxygen. M. Demarquay injected nitrogen into the peritoneum and cellular tissue of animals, and came to the conclusion that more or less exhalation from the lungs, etc., of the normal gases of the blood was caused by it (Archives Gén., 1859).

THERAPEUTICAL ACTION.—*External.*—On the hypothesis that the stimulation of ordinary air caused irritation and suppuration in wounds, stumps, etc., M. Demarquay was led to try the effect of enclosing them in caoutchouc bags full of nitrogen; but the practice was not successful.

THERAPEUTICAL ACTION.—*Inhalation.*—It has been proposed to utilize nitrogen by adding a larger than normal proportion of it to ordinary air for inhalation in irritable and inflammatory lung-condition, but no definite results have been obtained in this country. Steinbrück (Vienna) has, however, lately recom-

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mended nitrogen-inhalations in the first and second stages of phthisis in young persons, stating that "they lower the circulation, and allay nerve-irritability, give great relief, and sometimes cure"; in the third stage they are injurious (Dobell's Reports, 1876). I have not seen any confirmation of these results. The power of nitrous oxide as an anæsthetic has been largely developed in recent times (*v.* Anæsthetics).

HYDROGEN, H, = 1.

Hydrogen, being the lightest of known elements, is commonly taken as a standard of specific gravity and combining proportion. It has been found free in small proportions in certain volcanic gases, and occurs extensively in combination, *e.g.*, in water, in many acids and gases, in hydrocarbons, and all substances used for artificial light—tallow, oils, coal gas, etc. —and throughout the vegetable kingdom. It was formerly known as "inflammable air," and when lighted burns with a bluish flame.

PREPARATION.—By acting on granulated zinc with dilute sulphuric or hydrochloric acid—$Zn + H_2SO_4 = ZnSO_4 + H_2$.

CHARACTERS.—A colourless, inodorous gas, of sp. gr. 0·0692.

PHYSIOLOGICAL ACTION.—This is negative in character. Hydrogen does not support respiration or combustion, and Priestley ascertained that animals immersed in it died as soon as in carbonic acid. Beddoes found that attempts to inhale it caused cyanosis of lips and face, quickness and smallness of pulse, vertigo, impaired vision, and in some persons, drowsiness, slight insensibility, and when pushed, asphyxia in greater or less degree. A mixture with oxygen, when inhaled, causes the voice to become shrill.

THERAPEUTICAL ACTION.—Dr. Beddoes used hydrogen gas as an inhalation in phthisis, both by itself and in mixture with oxygen. He reported some cases as relieved and others

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cured, but his results have not been corroborated. The most constant effect seems to have been the production of sleep.

HYDROGENII PEROXIDUM—PEROXIDE OF HYDROGEN,

H_2O_2, = 34.

PREPARATION.—By acting on barium peroxide with hydrochloric acid.

CHARACTERS.—This compound of hydrogen is a liquid of the consistence of syrup, of strong, disagreeable, metallic taste, very unstable, and readily parting with its oxygen; hence it is a powerful oxidizer. It blanches a solution of litmus. A solution, of sp. gr. 1006, is in common use abroad for bleaching purposes, and is said to be permanent.

PHYSIOLOGICAL ACTION.—*External.*—This liquid, applied locally, whitens the skin and mucous membranes, and acts as a moderate caustic. It has also marked antiseptic power, though not equal to carbolic acid in that respect. Urine mixed with one-tenth of peroxide remained nine months without putrefying (Guttmann). The patent disinfectant termed "Sanitas" is said to depend for its efficacy mainly upon this peroxide.

PHYSIOLOGICAL ACTION.—*Internal.*—It produces, when given internally, some oxidizing, stimulating, and, in full doses, irritant effects. The bleaching solution, of sp. gr. 1006, has been used by Assmuth, Schmidt, and Guttmann for hypodermic injection in animals, and found to cause dyspnœa, clonic convulsions, and death in a few minutes from asphyxia. The last-named observer traces this to the development of bubbles of gas in the right cavities of the heart, the blood frothing up as if air entered by the veins. The result is partially antagonized by injection of ferrous sulphate, implying the combination of this with part of the oxygen liberated (Abstract, Med. Times, ii., 1878).

THERAPEUTICAL ACTION.—*External.*—**Ulcerations.**—Lotions containing peroxide have been used with advantage in soft chancre, and in cases of fœtid ulcerations of the mouth.

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THERAPEUTICAL ACTION.—*Internal.*—**Chronic Dyspepsia.**—Richardson, Guttmann, and others have reported improvement of the digestion under this remedy, but it is not much used.

Diabetes.—Cases of this disorder treated successfully by peroxide of hydrogen have been recorded (B. M. J. and Lancet, 1868), and much good was at one time expected from it as an oxidizing agent: but Dr. B. W. Richardson, who introduced the remedy, and used it in more than two hundred cases, came to the conclusion that although it could reduce the sp. gr. of the urine, it, at the same time, increased its quantity, and had no really good effect (Med. Times, ii., 1868). Dr. Pavy tried it in a few cases without any result (On Diabetes, p. 268).

Cyanosis—Pulmonary Congestion (Passive).—In these conditions, where oxygenation of the blood is defective, and which are generally connected with heart-disease, I have sometimes seen advantage from the internal use of peroxide of hydrogen—it is worth trial, but further observations are needed for estimating its true powers. Dr. B. W. Foster has reported two cases of congenital cyanosis relieved by it (Clinical Medicine, 1874).

Phthisis—Struma.—I have no personal experience of its use in these diseases, but benefit has been reported from it. In early stages it is said to improve digestion, in later stages to relieve dyspnœa, and in struma to cause absorption of glandular swellings (Ranking, 1868).

Pertussis.—Much power has been claimed for peroxide of hydrogen in the relief of paroxysms of whooping-cough, but I have no experience of it. In a severe case, complicated with cyanosis, in a child with patent foramen ovale, Dr. Mackey used the remedy with apparently good result for the time: the degree of cyanosis was less whilst the remedy was taken, and the attack of pertussis ran a mild course.

PREPARATIONS AND DOSE.—A solution containing ten volumes of oxygen is the one recommended by Dr. Richardson; an ethereal solution is preferred by others. Dose: Of the former 1 to 4 dr. freely diluted; of the ethereal solution ½ to 2 dr.

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CARBO, CHARCOAL, C, = 12.

Carbon is very widely distributed throughout all the kingdoms of nature; the diamond represents its purest condition, crystallized in the form of a regular octahedron. *Plumbago*, or *graphite*, the "black lead" of our pencils, is another form which is nearly pure, and is sometimes crystalline. This element combined with oxygen and various earths and minerals forms carbonates, as chalk and limestone, and combined with oxygen it occurs as carbonic acid in the air, and in many mineral waters. Two varieties of carbon are now officinal, in the form of charcoal prepared from wood, and from bones.

CARBO LIGNI—WOOD CHARCOAL.

PREPARATION.—By burning wood in covered heaps or in closed vessels, in such a manner as to almost entirely prevent the access of air. The oxygen, hydrogen, and nitrogen of the vegetable substance are driven off, and about 20 per cent. of carbon remains with a small proportion of earthy salts—carbonates of potash and lime, etc. A pure charcoal may be obtained from the combustion of oils or resins with insufficient oxygen, and is known as lampblack. For medicinal use, either kind may be further purified by ignition in a closed vessel to a red heat.

CHARACTERS.—Wood charcoal occurs as a black powder, or in black brittle pieces, very light, and retaining the shape and texture of the original wood. It is distinguished from purified animal charcoal by leaving a bulky white mineral ash, which is the 1 or 2 per cent. of mineral salt.

CARBO ANIMALIS—ANIMAL CHARCOAL—BONE BLACK.

PREPARATION.—By exposing the bones of animals to a red heat without access of air. Thus prepared, it contains 10 to 20 per cent. of charcoal, the remainder being mostly phosphate and carbonate of lime with some iron sulphuret. It may be obtained from any animal substance, a good quality being procured from dried blood.

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CARBO ANIMALIS PURIFICATUS—PURIFIED ANIMAL CHARCOAL.

PREPARATION.—By digesting the commercial charcoal with dilute hydrochloric acid for two days in a warm place; filtering, washing, drying the residue, and igniting in a closed crucible. By these processes the salts are rendered soluble, and removed as superphosphates and soluble chlorides, whilst carbonic acid and sulphuretted hydrogen gases are driven off.

CHARACTERS.—It occurs as a smooth, black powder, which has no odour and scarcely any taste; when burned it leaves very little ash. Charcoal has certain chemical and mechanical properties which are very useful in pharmacy. That prepared from wood is used as a deoxidizing agent, as in the preparation of sulphurous from sulphuric acid (by distilling the latter with it), and the reduction of iodate to iodide of potassium. Animal charcoal is used as a decolorizer in the preparation of alkaloids, etc. Its power in this respect is such that diluted tincture of litmus will filter through it colourless. Warrington ascertained that it would remove the bitterness of hops and other vegetable infusions, and Dr. Garrod soon afterwards pointed out that it would destroy the activity of many organic poisons, as opium, aconite, and nux vomica (Lancet, ii., 1845). Animal charcoal is much more powerful as an antidote than that prepared from wood.

Both varieties possess great absorptive power, taking up more than twice their weight of gases, and may be used for purifying water by filtration, and for the disinfection of sewer emanations, and the deodorizing of sick rooms, dissecting rooms, etc. (Letheby). A respirator containing a layer of charcoal has been recommended (Stenhouse, Marcet).

THERAPEUTICAL ACTION. — *External.* — **Fœtid Discharges.**—Charcoal is used in surgery to cleanse and alter the condition of old and sloughing ulcers, suppurating sores and wounds, and is sometimes applied directly to them in the form of powder, or poultice with bread: to relieve offensive odours it is better enclosed dry in muslin bags and placed near the

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wounds. In open cancer a paste of soot with glycerine is said to be a useful application (Debreyne, Med. Times, i., 1860, p. 402). For offensive perspiration of the feet or axillæ, charcoal may be mixed with alum or zinc oxide and used as a dusting powder: with chalk it forms a cleansing dentifrice.

CAUTERY.—Charcoal "pegs" have been used as a cautery—they are mixed with nitrate of potash (Lancet, ii., 1866, 309).

THERAPEUTICAL ACTION. — *Internal.* — For ordinary medicinal use, wood charcoal is commonly preferred.

Dyspepsia, Flatulence, etc.—It is very useful for patients suffering from pain, weight, and sense of fulness at the epigastrium with flatulent distension, acidity, sour or bitter eructations, nausea or vomiting, furred tongue, foul breath, and with a tendency to loose, ill-formed motions. These stomach-symptoms are usually accompanied with palpitation.

The charcoal powder, which acts by absorbing intestinal gases and neutralizing offensive products of decomposition, should be perfectly fresh and taken dry, and preferably at the commencement of a meal. The dose need not be so large as a teaspoonful, which is commonly given; in many cases I have found 2 to 5 gr. sufficient. Bismuth and magnesia are sometimes advisable at the same time.

Diarrhœa.—Charcoal acts well in the diarrhœa of scrofulous children when the stools are small, slimy, and light-coloured, with intermediate troublesome discharge of flatus and itching of the anus; also when the attacks have depended upon irritation of the mucous membrane from undigested food, etc. It may be well given with milk (*cf.* Med. Record, March, 1881). Rhubarb is often usefully combined with it in the cases described.

Charcoal is also serviceable in the atonic irritative diarrhœa of old people, but I have more than once known intestinal hæmorrhage occur after its use. If large quantities be given, some may be retained and act as a mechanical irritant, so that the remedy is not so innocent as commonly thought.

Dysentery.—Charcoal has been recommended in dysentery, and its antiseptic powers may be serviceable in chronic cases. The putrid smell of the discharges may certainly be relieved by

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a few doses of 30 to 60 gr., but it returns on discontinuance of the remedy—the effect is a temporary chemical one.

Dr. Farre has reported cases in which it has acted equally well when given in enema (Ranking, ii., 1862).

In **Enteric Fever** charcoal lessens the distension of stomach and intestines, and when mixed with magnesia sometimes proves still more beneficial.

Cancer of Stomach—Gastric Ulcer.—In these organic diseases many of the distressing symptoms may be relieved by charcoal.

Ascarides.—A daily dose of charcoal mixed with salt, and given in the early morning, has been found useful in destroying and preventing the development of these parasites.

PREPARATIONS AND DOSE.—*Of wood charcoal* many varieties are in use, some practitioners giving the preference to that made from heavy woods (box, acacia, etc.), others to the light woods (poplar or willow). Dr. A. Leared recommended that made from "vegetable ivory." Charcoal from the hæmatoxylon campechianum is good, but has been over-praised. Belloc's is also a good preparation, it is made from poplar. Biscuits and lozenges of charcoal are also used, but in my experience are not so effective as the powder; and they sometimes irritate the stomach. *Carbo ligni:* dose, as antacid, antiseptic, or absorbent, 10 to 60 gr., or more. *Cataplasma carbonis* ("charcoal poultice") contains ½ oz. of wood charcoal. *Carbo animalis* is to be preferred as an antidote to poisons: dose, from ½ oz. to 2 oz. or more, according to the amount of poison swallowed: it is best taken suspended in water. *Carbo animalis purificatus:* dose, 20 to 60 gr. or more.

SULPHUR, S, = 32.

This element occurs in the animal kingdom as a constituent of the albuminous (protein) tissues, of bile, of cystin, etc., and in the vegetable kingdom in many essential oils and resins, such as those of mustard, horse-radish, garlic, and asafœtida. In volcanic districts it is found native, and in many places it is met

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with combined with metals, as sulphide, or "pyrites"; the bisulphide of iron contains more than half its weight of sulphur. United with hydrogen or with alkalies, it is found in many organic substances and mineral waters, and with oxygen it forms sulphuric acid and the various sulphates.

CHARACTERS AND TESTS.—Sulphur occurs in commerce either as a gritty powder, or in round sticks (roll sulphur—brimstone), or in crystals; it is opaque and brittle, pale yellow in colour, of insipid taste, and emitting a peculiar odour if it be rubbed; it is inflammable, burning with a bluish flame and evolution of sulphurous acid gas. Sulphur melts at 115° F.; at greater heats it becomes amber-coloured, then brown, and gradually thickens until the containing vessel may be inverted without spilling it; it is insoluble in water, slightly soluble in alcohol (absolute alcohol dissolves nearly 1 per cent.), partially soluble in fixed and volatile oils and bisulphide of carbon. Hydrochloric acid added to sulphur or its compounds causes evolution of sulphuretted hydrogen, which will be known by its characteristic odour.

OFFICINAL FORMS.—Two varieties of sulphur are placed in the Pharmacopœia—the sublimed and the precipitated.

SULPHUR SUBLIMATUM—SUBLIMATED SULPHUR—FLOWERS OF SULPHUR.

PREPARATION.—By melting or burning the native sulphur-earth, or any metallic sulphide, and condensing the vaporized sulphur in large chambers.

CHARACTERS.—Sublimed sulphur is a gritty powder, canary-yellow in colour, and possessing the characters of the element as already described. It may be acid in reaction from the presence of a little sulphuric acid, formed by slow oxidation, and should be freed from this by washing with distilled water, after which it becomes "sulphur lotum."

SULPHUR PRÆCIPITATUM—PRECIPITATED SULPHUR.

Called also lac sulphuris (milk of sulphur), though this name was originally given to an old preparation made with lime sulphate.

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PREPARATION.—From the sublimed sulphur, by first boiling it with slaked lime until the substances combine, and then adding hydrochloric acid, which unites with the lime whilst the sulphur is precipitated.

The reactions are somewhat complex, but may be thus represented: $3CaH_2O_2 + 6S_2 = 2CaS_5 + CaS_2H_2O_4 + 2H_2O$ and then, on adding the acid, $2CaS_5 + CaS_2H_2O_4 + 6HCl = 3CaCl_2 + 4H_2O + 6S_2$.

The precipitated sulphur should be dried at a heat of 120° F.

CHARACTERS.—A pure specimen is of pale dead-yellow colour, without odour or taste, very smooth to the touch, not readily diffused in water. Under the microscope it presents opaque rounded granules, separate or in clusters.

SULPHIDES OR SULPHURETS.

Sulphurated potash (hepar sulphuris, or "liver of sulphur") (*v.* Potash) and *sulphide of calcium* (hepar calcis, or "liver of lime") are in common medical use, and the sulphides of sodium and of ammonium are found in many of the sulphurous mineral waters. Their action is somewhat similar to that of sulphur, perhaps more powerful. The *sulphide of calcium* (not officinal) is found native, or may be prepared artificially by calcining, in a closed vessel, equal parts of sublimed sulphur and pulverized oyster shell (a pure form of lime carbonate). It is a yellowish-white powder of sulphurous taste and odour. *Hypochloride of sulphur* consists of "flowers of sulphur" impregnated with a small quantity of chloride of sulphur (S_2Cl_2), obtained by passing chlorine over sulphur. It is apt to explode if kept in full glass bottles closely corked.

ABSORPTION AND ELIMINATION.—It has been stated, though not satisfactorily proved, that finely-divided sulphur may pass as such into the blood. Eberhard states further that he has seen it in the lymphatics, and Griffith that he has found it excreted in the urine, but these statements lack confirmation, and are not easy of credence.

It is more probable that, before absorption, under the

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influence of alkaline saliva and mucus, and the secretion of intestinal glands, an alkaline sulphide is formed, part of which is decomposed in the intestine (the resulting sulphuretted hydrogen being passed as flatus), and part oxidized, since its administration increases the urinary sulphates (Regensburger, Centralblatt f. Med., 1877). Of any ordinary dose of sulphur a certain proportion passes out unchanged and unabsorbed in the fæces. Fatty substances are said to promote absorption of sulphur, though the experiments of A. Krause (1853) scarcely support this view. He found that when equal doses of sulphur were given either with or without fat, the amount of sulphates excreted by the urine was the same.

The sulphuretted hydrogen which is absorbed is eliminated by the skin, the bronchial membrane, and by the various glands, and gives indication of its presence, both by its odour and by staining silver articles worn about the person. Orfila detected it in the urine.

In exceptional cases the gas may be formed in, and absorbed from, the intestine with production of marked but temporary nerve-depression. I have not myself seen this *as an effect of taking sulphur* medicinally, and in cases where sulphuretted hydrogen has been injected into veins it has been so quickly eliminated by the lungs that the arterial current remained unaffected by it (C. Bernard). Dr. B. W. Richardson concluded from observations with "sulphur alcohol" that its compounds were *not* absorbed from the alimentary canal, but I believe that occasionally they may be so. In aged persons, and in some cases of hepatic and intestinal disorder, I have noticed attacks of depression coincident with flatulence and foul breath, and relieved by a stimulating purge; and Dr. Senator has recorded the case of an adult suffering from gastric catarrh, in whose breath and urine sulphuretted hydrogen had been detected, and who had more than one attack of collapse lasting for a few minutes and accompanied with pallor, giddiness, and small, quick pulse; he recovered after purgation (Berlin. Klin. Woch., 1868, No. 24).

PHYSIOLOGICAL ACTION. — *External.* — Applied with friction to the sound skin, sulphur causes a moderate degree

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of irritation; much more if the surface be excoriated. The alkaline sulphurets, such as those of potash and of lime, irritate severely, if used in strong and warm solution, to a delicate skin. Sulphur and some of its compounds have the power of destroying the lower forms of vegetable and even animal life; whence their practical value as "anti-zymotic and anti-parasitic" remedies. Binz attributes this power to the formation of *sulphurous acid* under the influence of exposure to the air, and to heat, and to contact with protoplasmic organisms (*e.g.*, the oïdium Tuckeri of the grape). The subject of disinfection is more fully considered under the heading of Sulphurous Acid.

PHYSIOLOGICAL ACTION.—*Internal.*—Given to animals it produces at first, at least, some stimulant effect. Benk states that its after-effect is of reverse character, and that this is accompanied by, and is probably due to, intestinal irritation. Hertwig found also that animals were readily brought under the influence of the drug with production of diarrhœa.

Circulatory System. — Sulphur and the sulphides, in moderate doses, stimulate the circulation, especially that of the capillaries, the skin and mucous membrane, and the venous circulation within the pelvis. Congestive headache, vertigo, and sometimes hæmorrhage have been traced to the use of the drug and of mineral waters containing it. Gubler, Mitscherlich, and many older authorities are agreed upon these points, and assert further that a rise in temperature and distinct pyrexia may be caused by sulphur, especially in plethoric persons.

Secretion and Excretion.—Buchheim and some modern writers express doubts as to whether sulphur really increases secretion from the bronchial mucous membrane and the skin; but I cannot agree with them, for I have frequently seen an augmentation of these secretions under the use of this remedy. According to Boecker the urinary water and solids are increased in amount under the action of sulphur, but this requires confirmation (Husemann).

Cutaneous System.—Some dark coloration and much

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irritation of the skin may occur from the internal use of sulphur. I have seen a red papular eruption from it, and also occasionally boils and carbuncles. The waters of Harrogate, Barèges, Aix-la-Chapelle, etc., have been known to produce such effects.

Digestive System.—The *sulphides*, in small doses, excite a sensation of warmth at the epigastrium; in excessive doses, they may cause gastro-enteritis, and even, it is said, "insensibility and speedy death" (Ringer). Sulphur itself in small doses excites a similar sense of warmth, sometimes gaseous eructations; sulphurous waters in the quantity of several ounces often cause pain and oppression in delicate subjects. Doses of 20 to 40 gr. and upwards of sulphur in powder cause moderate stools, semi-solid in character, and passed with perceptibly increased peristaltic action; hence it has been presumed that the muscular coat is mainly acted upon. Sundelin maintained that sulphur had a "specific" action on the mucous coat, but we cannot speak positively about this (Binz). The prolonged use of sulphur as an aperient induces intestinal catarrh.

Husemann supports the view that unabsorbed sulphur mechanically protects the intestinal mucous membrane like bismuth, and this would explain the fact that large doses relax without colic, whilst moderate doses relax equally but with some colic, and small doses cause pain without the relaxation.

SYNERGISTS.—As a stimulant, sulphur is aided in effect by the volatile oils; as an alterative, it has analogies with arsenic, phosphorus, and possibly iodine (Gubler); as an aperient, magnesia and the acid tartrate of potash assist its action.

Chemically, sulphur belongs to the same group as oxygen, selenium, and tellurium, and between oxides and sulphides there is much analogy.

ANTAGONISTS.—Sedatives, refrigerants, astringents, and cold oppose the ordinary action of sulphur; quinine and bromides have a specially antagonistic effect.

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THERAPEUTICAL ACTION.—*External.*—**Parasitic Skin-Diseases—Scabies.**—Sulphur is one of the substances which are fatal to acari, and it still remains one of the best, as it is the commonest, remedy for scabies, though Dr. McCall Anderson and others have objected to it as too irritant.

It is nearly certain that sulphur, when used by itself or mixed with lard, has simply a mechanical effect on the epidermis, but when carbonate of potash is added to the ointment, *sulphurated potash* is formed, and this compound quickly destroys the acari. We know, from clinical observation, that these insects often live in the plain sulphur ointment for several days without much apparent detriment, whilst, as Kuchenmeister says, "the acari, kept in a solution of sulphurated potash, die in a quarter of an hour."

The strength and the frequency of the application should be varied according to the delicacy of the patient's skin and the amount of the eruption; the more active the preparation, and the more thorough its use, the quicker will be the cure. Thus, painting the body with a solution of chloride of sulphur in sulphuret of carbon is said to cure in five minutes (Med. Times, i., 1856, pp. 247, 368); whilst Bourguignon's formula with lime and sulphur (boiled together) is allowed half an hour, and M. Hardy's method with soft soap frictions, warm bath, and anointing with 2 parts of sulphur to 8 of lard and 1 of potash carbonate, effects its purpose in four hours (Brit. and For. Rev., ii., 1852, Leçons); but such results are liable to be accompanied with unnecessary irritation and pain to the patient. Dr. Tilbury Fox, having seen eczematous eruptions and chronic irritation often induced by the excessive use of too strong an ointment, and founding his advice on observation of the parts usually affected, advocates the use of a mild ointment (1 part in 16, *i.e.*, ½ dr. to the ounce of lard) *to the wrists and between the fingers only*, in acute cases accompanied with general irritation (Lancet, ii., 1871); but, as Hebra and R. Liveing observe, the restriction of the application to a *few portions* needs very exact diagnosis, and, as a rule, the ointment of the selected strength should be applied to every part. A prolonged warm bath (half-hour), and thorough cleansing with soap and friction, should precede the inunction: then, after drying, either the mild

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ointment of Fox, or the simple ointment of the Pharmacopœia (1 part in 5), or one of intermediate strength (1 part in 8, with ½ a part of potash carbonate) should be plentifully rubbed over the trunk and the limbs, especially the flexor side of the limbs and between the fingers and toes; and then socks, gloves, drawers, and jersey should be used to keep the ointment in contact with the skin (Liveing). An ointment I commonly prescribe is made with sublimed sulphur, 2 dr.; sulphide of calcium, ½ dr.; and simple ointment, 2 oz. After a night's application, a warm bath in the morning may be used to remove the odour of sulphur, but then a second or third inunction may be required; if the first one can be left undisturbed for twenty-four hours, it will often suffice to cure. In some cases, a lotion of sulphuret of calcium (liquor calcis c. sulphure) acts better, because it is more thoroughly applied than an ointment; its use should also be preceded by a warm bath, and it need only be *gently* applied with a sponge or brush; if used with friction it may cause very severe irritation.

A sulphur-*bath* is not so efficacious as these remedies, but may sometimes be required, and may be made with half a pound of sulphurated potash to thirty gallons of water — or with sulphur, hyposulphite of soda, and acid (*v.* Preparations). Wooden or porcelain vessels should be used for the baths, of which several will be required. Sulphur in vapour may also be employed.

It is important to remember that irritation of skin may remain even after the scabies itself is cured, and this irritation is to be treated by soothing remedies; sulphur is not to be continued longer than absolutely necessary for the destruction of the parasite. Sometimes it may be altogether contra-indicated, or may be inconvenient, and then recourse may be had to styrax, tolu, petroleum, or iodide of potassium; but in most cases the preceding method will give satisfactory results.

Tinea Tonsurans—Chloasma.—The parasites in these maladies are curable by sulphur applications, but a compound ointment containing ammoniated mercury acts better than simple sulphur ointment (Ung. hydrarg. ammon., with an equal part of Ung. sulphuris, is a good formula).

Sycosis Mentagra ("**Barber's Itch**").—In this disease

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Hebra advises that the affected hairs should be pulled out, and then a paste containing sulphur, glycerine, and alcohol, in equal parts, should be rubbed over the diseased skin every night and morning; by this means a cure is rapidly effected, but it is rather severe treatment. It is specially adapted for the parasitic form, but is useful also in the more common one, because sulphur, as well as sulphides, lessens pus-formation.

Prurigo. — In chronic prurigo — especially when connected with phtheiriasis, but also in independent forms— an ointment containing sulphur with a preparation of tar is often of much service. Anderson recommends 6 dr. of pix liquida in 4 oz. of ordinary sulphur ointment (Lancet, ii., 1869). Sulphur vapour baths are useful. In ordinary pruritus I find a lotion of sulphurated potash very effective (*v.* p. 44).

Eczema-Psoriasis.—When eczema occurs as a complication of scabies, Hebra joins with the sulphur an equal quantity of tar and half the quantity of chalk; and there are some stages of idiopathic eczema when sulphur acts as a useful stimulant, viz., when the eruption is on the *decline*, but remains in obstinate chronic patches, especially about the legs. It acts best in lymphatic constitutions; but, as a rule, I prefer potash or tar applications to sulphur. I may say the same as to my own experience in chronic psoriasis, but compound sulphur ointments have been found useful in this malady; and part of the benefit following the use of caoutchouc bandages has been traced to the sulphur they contain (Hebra). Dr. Wetzler states that ordinary psoriasis, when not much developed, can be cured by the Aix-la-Chapelle waters alone, if prolonged baths can be borne. In very extensive and obstinate cases, however, he adds iodide of potassium to the water, and prescribes in addition sulphurous vapour baths, tar-frictions, etc., and it is stated with the best results (Practical Treatise, 1862, p. 66).

Acne.—With the exception of scabies, acne is the skin-disease in which sulphur is most frequently used and gives the best results; the degree of stimulus or irritation supplied by it seems more appropriate than that of any other application, unless it be sometimes mercury. In the *simple acne* of young people, occurring in the sebaceous glands about the face and shoulders, accompanied by comedo and without

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much general congestion, a fairly strong preparation may be used, such as the sulphur ointment of the Pharmacopœia; or potash may be added to it (Lancet, ii., 1878), or a lotion containing 6 dr. of precipitated sulphur and 1 dr. of glycerine, with 6 oz. of rectified spirit (Anderson). When a moderate degree of irritation is present the proportions may be altered; thus, 1 dr. of sublimed sulphur may be rubbed up with a little alcohol, and then 2 dr. of the smoother variety may be added, with water to dilute sufficiently (Morris, Lancet, i., 1855); or a lotion that I commonly use with advantage is made with 2 to 4 dr. of precipitated sulphur, with the same quantity of spirit and glycerine, in 6 oz. of rose water. Spirits of camphor or ether may be added, to relieve itching or heat, and special indications for internal treatment must be considered. Sometimes dusting with the pure dry precipitated sulphur answers better than anything (Parsons, B. M. J. i., 1879). The local remedies should be lightly or firmly applied, according as they can be borne, left in contact all night, and washed off with mucilaginous decoctions or water in the morning.

For *acne rosacea*, one of the best applications is an ointment containing 2 dr. of the hypochloride of sulphur in the ounce of rumex ointment (Wilson), or a lotion of ½ oz. of sublimed sulphur in 4 oz. of elderflower water. The ointment of *iodide of sulphur*, which is still stronger, may be carefully used to chronic cases of any form of acne. A certain amount of temporary irritation must be expected from these remedies, and may require their occasional intermission, and the use of sedatives; but some compound of sulphur, judiciously employed, will be found the most effective cure. The internal use of calcium sulphide should be conjoined with this treatment.

Burns—Scalds.—Dr. Myrtle, of Harrogate, has recommended sulphur ointment as a good application for burns and scalds (Edin. Med. Journ., 1862).

Granular Ophthalmia.—Wharton Jones has found advantage from the use of sulphur ointment as a stimulant, a small quantity being applied between the lids at bedtime (Med. Times, i., 1859). There are, however, better applications than this.

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Rheumatism.—The friction of rheumatic limbs with sulphur is as ancient at least as Pliny (Lib. xxxv.), and attention was specially directed to it again some years ago by Dr. Fuller, Dr. O'Connor, and others (Med. Times, i., 1858). They found it useful also in sciatica and lumbago, adding to the frictions close and constant covering with flannel. Rénard found it very serviceable in rheumatism affecting tendinous parts, in his own person, after an acute attack; it produced some degree of heat and increase of perspiration when it acted well. It should certainly be tried in all obstinate forms of rheumatism, and especially that form which attacks the soles of the feet in those who are exposed to damp and cold.

It is in the different forms of chronic rheumatism and chronic skin-disease, that baths of sulphurous waters, as at Barèges and Aix-la-Chapelle, are found most valuable.

THERAPEUTICAL ACTION.—*Internal.*—The therapeutical action of sulphur and the sulphides is somewhat similar, but the former is commonly used in small doses to produce an "alterative," and in large doses a laxative effect, and the latter to modify some acute conditions, especially when they are connected with suppuration in various stages.

Skin-Disease.—The *internal* use of sulphur for many skin-diseases rests on an old tradition, but is not much adopted in modern practice. I have tried it extensively, and although the alkaline sulphurous waters are useful sometimes, and in *acne rosacea* the calcium sulphide in ¼ to ½-gr. doses thrice daily, seems to help absorption of the tubercles and abate venous hyperæmia, yet with these exceptions, I have not seen much advantage. Dr. Cane refers to sixteen cases of acne in which the last-named remedy was useful (Lancet, ii., 1878).

Scrofula—Swollen Lips, Glands, etc.—Scrofulous children are often disfigured by a chronic swelling of the upper lip and alæ nasi, which may be connected with a crack or fissure on the inner surface of the mucous membrane. Accompanying this condition, there often exists a tendency to dyspepsia and indolent swelling of the mesenteric, cervical, or other glands.

Although we cannot wholly cure the constitutional tendency

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in such cases by sulphide of calcium, yet I have seen their general condition greatly improved by small doses (¼ gr.) given night and morning for a few weeks—the fissure has healed and the lip-swelling subsided, and the glands have grown less.

In cases where pus has actually formed in some of the glands, the effects of this remedy may readily be traced in the subsidence and disappearance of some of the swellings, whilst others progress quickly, maturate and discharge, and others that have been open and discharging unhealthily for some time take on healthy action, and ultimately contract and heal. For permanent good results this treatment should be followed up by cod-liver oil and generous diet, and if possible change to the seaside. As a rule frequent doses of the sulphide are not desirable, as they are apt to derange the stomach and cause troublesome eructation of sulphuretted hydrogen.

Scrofulous Ophthalmia, etc.—In this affection I can recommend sulphide of calcium, and especially when ulceration of the cornea is present; it also acts well in scrofulous otorrhœa, and indeed in almost all purulent discharges occurring in children, especially when becoming fœtid and obstinate in character.

Suppuration.—Calcium sulphide exerts a marked influence on the formation of pus. If given early, it controls the inflammatory process, either aborting it so that it does not go on to suppuration, or if this take place, controlling and limiting its extent, promoting a more healthy formation, quicker evacuation, and more rapid subsequent healing.

In the treatment of simple *abscess* I have frequently used it with much advantage; in tonsillar abscess (quinsy) it is particularly valuable, and may save recourse to incision; and in mammary abscess, if the time for belladonna or antimony is past, the sulphide is quite the best remedy. It has seemed to me to check the spread of the inflammation, and to help quickly to evacuate matter, and so shorten the tedious course common in this malady. Should hardness and pain continue after an opening has formed, and should the discharge come away incompletely, the remedy must still be continued, and is likely to exert a favourable influence.

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In *bubo*, especially if indolent, and with scanty, unhealthy pus-formation, the sulphide will often determine a more healthy action; ¼ to ½ gr. in pill every three or four hours is a suitable dose.

In ordinary *boils*, and in *carbuncles*, also a compress moistened with sulphide of calcium lotion—(4 gr. to the pint of water)—should be applied. When eruptions of boils recur at intervals, I commonly advise a course of the precipitated sulphur—5 to 10 gr. night and morning—for several weeks during the intervals, but at the time of actual maturation, recommend the sulphide as acting more quickly. Even in *pneumonia*, in those exceptional cases when the exudation in later stages degenerates into pus, I have seen benefit from the same remedy: it has equally seemed to assist evacuation of matter already formed, and to check the tendency to its fresh formation.

Syphilis.—In most of the later manifestations of this disorder, sulphurous waters have a good reputation, but in my opinion without sufficient reason. At Aix-la-Chapelle, for instance, the treatment is conducted mainly by mercurial inunction, and the sulphur waters used locally and internally can only be considered adjuvants to this more powerful remedy. I think they serve mainly to cleanse and stimulate the skin, to regulate the action of the bowels and viscera, and to counteract any injurious effects that might arise from the mercury (*v.* p. 219). They have, perhaps, a further use for diagnostic purposes, since it is said that obscure symptoms really due to old or latent syphilis manifest themselves more fully under a course of the waters, and thus give the necessary indications for treatment by iodides or mercury. Dr. Wetzler gives several instances of this (op. cit.), and I have no doubt of its possibility.

I must say also that I have seen advantage from the use of sulphide of calcium in *syphilitic laryngitis*, notably when mercury had been previously taken to saturation.

Diphtheria.—During certain stages of this malady, preparations of aconite, iron, iodine, bromine, etc., are indicated, as described under those medicines, but at the time when pus is commencing to form, and the false membrane is becoming somewhat loosened from the mucous surface, the sulphide of calcium is often useful, for it exerts the action already referred to, of

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assisting to healthy completion and at the same time limiting the extent of the suppurative process. We know that this formation of pus-cells occurs as part of the diphtheritic inflammation before the return of healthy conditions, and as remarked by Mackenzie (who does not, however, mention this remedy), "when it is found impossible to check the formation of lymph it is rational treatment to convert, as far as we can, the inflammatory into a suppurative process" (On Diphtheria, 1879). If commenced early in this stage in doses of $\frac{1}{10}$ to $\frac{1}{4}$ gr. every one or two hours it produces the best effects, but it is useful also even if begun after pus-formation is fully developed, and I believe it has some influence in lessening blood-poisoning. The value of steam-inhalation in helping on the natural changes of diphtheria and the formation of muco-pus and loosening of the membranes has been often proved (P. James, Oertel) and is now well known. I find it still more efficacious if the sulphide of calcium be added to the boiling water in the proportion of about 4 gr. to the pint, so that a certain amount of sulphurous vapour is locally applied.

The local insufflation of finely-powdered sulphur has been credited with arresting the development of diphtheritic exudation (Practitioner, Nov., 1868, vi.), but has disappointed expectation. Oertel concludes, after much experience, that it acts only as a "scouring powder," wearing off the membranes by friction; it has no influence at the onset of the malady, but has seemed to answer only when purulent infiltration and fibrinous exudation have already ceased. It has an antizymotic but no other specific power, and is liable to cause irritation (B. M. J., Jan. 11, 1879).

Mr. Erskine Stuart has, however, written still more recently in favour of local applications of precipitated sulphur. According to his latest experience, "it is best applied, after being rubbed up with a little water, on a swab to the affected part; it is free from grittiness, it sticks better, and hence exerts its action for a longer time, and is applied more safely in this manner than by insufflation." He states, "that every case treated with sulphur made a rapid recovery" (Practitioner, Oct., 1879), but the number apparently is not more than six, and he unduly depreciates other remedies.

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In Laryngo-tracheal Diphtheria (Croup), when we cannot always see the false membrane, I find the sulphide of calcium treatment indicated if wheezing, rattling sounds accompany the breathing, *i.e.*, when the membrane begins to be loosened, rather than in the first stage when the breath-sounds are of dry and sawing character.

Chronic Sore Throat.—Dr. Guéneau de Mussy has specially pointed out the value of sulphur waters in "glandulous angina," which under ordinary treatment is an obstinate malady. The waters of Eaux Bonnes are of remarkable efficacy in such cases (*v.* Mineral Waters); the sulphurous acid spray is also useful if not too irritating.

Scarlet Fever.—Mr. Pigeon believes that in sulphur he has found the true remedy for this fever, and he certainly applies it very thoroughly, and appears to have had good success. He anoints the patient twice daily with sulphur ointment, gives 5 gr. of sulphur by the mouth twice daily, and fumigates frequently with sulphur vapour (Lancet, ii., 1876).

Variola.—Sulphide of calcium, I believe, often moderates excessive suppuration in this malady.

Asthma—Chronic Bronchitis.—In cases with much cough and profuse secretion, sulphur will often relieve, lessening and modifying the expectoration. I have seen this accomplished in many instances. The old physicians described it as "balsamum pectoris," and it still forms part of some quack "nostrums." Dr. Graves records his experience in its favour. Binz suggests that sulphuretted hydrogen being excreted by the bronchial mucous membrane may partially narcotize the terminals of irritated bronchial nerves, and advocates for the continued use of small doses of sulphur in asthma are not wanting (Duclos, Bulletin, 1861). I have seen cases marked by loud wheezing, profuse but difficult expectoration, troublesome palpitation, and nocturnal spasms of severe dyspnœa, improve quickly with 5 to 10 gr. of sulphur taken thrice daily. The sulphur springs of Weilbach are celebrated for relieving cases of chronic bronchitis, especially when complicated with hæmorrhoids.

Phthisis.—Sulphur was well known to the ancients as a remedy in consumption, and Galen ordered to phthisical patients inhalation of the vapour from the crater of Etna. It is not

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much used internally in modern practice, but for chronic phthisis the springs at Weilbach have a favourable reputation.

Sutro finds sulphur of good service in some cases of phthisis, and the presence of hæmorrhoids is one indication for it; he suggests that it combines with the iron of effete blood-corpuscles, quickens the elimination of this and other residua, and thus relieves the portal system and indirectly the lungs (Med. Times, i., 1862, p. 362), and I quite agree with those observers who have noted, in this disease, much advantage from the use of sulphur both internally and by inhalation. Dr. Dewar relates instances where sulphurous acid and steam acted unexpectedly well on phthisical subjects exposed to them (Med. Times, i., 1867). A spray containing sulphurous acid facilitates expectoration, and also disinfects and lessens purulent secretion, and so far relieves certain symptoms, but has no specific power over the disease.

Chronic Rheumatism.—Sulphur frictions for rheumatism have been already mentioned, and the drug was formerly considered a good internal remedy for chronic muscular and articular pain, and no doubt it is often of real value when given in doses of from 5 to 20 gr. twice daily for some time—I think the smaller doses give the better results. Remedies calculated to produce diaphoresis, such as vapour baths, should be generally combined with its use. In acute articular rheumatism it has little or no power.

Paralysis.—In chronic and asthenic cases of impaired motor power, the use of sulphur internally and externally deserves a fair trial. Dr. Graves was accustomed to depend upon it after a course of strychnia. Wetzler has recorded four cases of progressive muscular palsy benefited by warm sulphur baths and the administration of the water at Aix-la-Chapelle (Brit. and For. Rev., ii., 1856, p. 457), and in his treatise (1862) has added several other cases. Althaus found these remedies useful in locomotor ataxy (Lancet, ii., 1865). I have also seen some advantage from them in the latter condition.

Mercurial Tremor — Mercurialism.—In cases of palsy and tremor connected with the action of mercury, sulphur is useful (Lettsom) and deserves trial; it is said also to neutralize acute mercurialism accompanied with salivation, etc., and may be given in 5 to 10-gr. doses at the same time as chlorate of

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potash. On the other hand, in patients who have taken mercury at some previous period, sulphur, like iodides and other powerful alterants, has sometimes determined a fresh salivation.

Lead Colic—Lead Palsy.—In these conditions sulphur has been found available, though iodide of potassium is now proved to be better. In an epidemic of lead-poisoning at Havre, M. Marguerette found sulphur give much relief; it required to be exhibited at first in very large doses (50 grammes in the first day), being afterwards gradually diminished as the symptoms improved (Bulletin, Oct., 1867).

Hepatic Disease.—Chronic enlargement of the liver, with obstruction to the portal circulation, accompanied as it usually is by hæmorrhoids, is often much benefited by a course of sulphur, or of calcium sulphide, or potassium sulphide.

Constipation—Hæmorrhoids.—The mild action of sulphur on the mucous membrane, or muscular coat of the intestine, renders it a useful aperient for children and delicate persons, especially if there be congestion about the rectum or pelvic viscera. In cases of hæmorrhoids it is one of the best laxatives, and if not powerful enough may be combined with tartarated potash, or with confection of senna. A "compound liquorice powder," in which sulphur is the main ingredient, has recently been introduced into the B.P., but the Prussian formula, which includes also finely-powdered senna, is superior. In the treatment of piles sulphur need not be given in quantity sufficient to produce a laxative effect, unless this is otherwise required, for it can relieve by virtue of a stimulant and tonic action on the venous and capillary circulation, especially of the rectum and pelvic viscera, without any direct aperient action. The ordinary dose should be 5 to 10 gr. morning and night. Weak sulphur ointments locally applied increase the good result. The remedy may also be used in the form of vapour, and if the fumes from burning sulphur can, by means of apparatus, be applied directly, they often relieve congested, painful, and bleeding piles—this is a popular domestic "cure" in some parts of the country (Pairman). Dr. Thorowgood attributes to sulphur a special value in torpor of the colon, which often causes or complicates dyspepsia; he recommends 10 to 20 gr. to be taken in the early morning

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with nux vomica; the lozenges of Holsverck contain the same ingredients (Lancet, i., 1869; Times, i., 1858, p. 457).

Diarrhœa—Dysentery—Cholera.—Dr. Blacklock, of the Madras army, and Dr. Graves quote an extensive experience in favour of the efficacy of sulphur in these maladies; the latter observer combines it with soda and spirits of lavender, and in severe cases with opium (On Cholera, 1865). Mr. Prosser also finds drachm doses given with mucilage to be "one of the best remedies in epidemic diarrhœa and cholera" (Lancet, ii., 1866, p. 483). This is not a general experience, nor is it mine, although I have found sulphur in 2 and 3-gr. doses useful in the fœtid, watery diarrhœa of scrofulous children; also in some cases of chronic dysenteric diarrhœa with tenesmus.

Disorders of Menstruation.—When the menses are delayed in weakly and phlegmatic persons, sulphur used as an habitual laxative has some influence in bringing on the flow; on the other hand, it has been recommended for relieving uterine congestion and its consequences at the climacteric period (Tilt).

Ascaris Vermicularis.—Precipitated sulphur is often a simple and efficient remedy for these parasites; 5 to 10 or 15 gr. should be given daily, morning and night, for some weeks.

PREPARATIONS AND DOSE.—*Pure precipitated sulphur* is more finely divided, and is thought to be more active, than the sublimed form; the dose of either is, however, the same, 5 to 10 gr. as a stimulant, 20 to 60 gr. as a laxative; it is well given in milk, honey, or treacle. *Confectio* (made with *sublimed sulphur*): dose, 60 to 120 gr. *Unguentum* contains 1 part to 4 of benzoated lard. A milder and often more useful form of ointment is made with half the amount of sulphur, and ½ dr. of carbonate of potash to the ounce: essence of lemon conceals the odour (Squire). *Solutio calcis c. sulphure* may be prepared by boiling together 1 oz. of quick-lime and 5 of sublimed sulphur in 1 pint of water for half an hour; filter and make up, if necessary, to half a pint; a similar solution is now commonly sold by wholesale chemists.

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Lotio potassæ sulphuratæ may be prepared with 1 dr. to half a pint of water for use in irritable skin-eruptions. *Balneum potassæ sulphuratæ:* ½ lb. to 30 gallons of water in porcelain or wooden vessel. *Balneum sulphuris compositum* (Startin): precipitated sulphur, 2 oz.; hyposulphite of soda, 1 oz.; dilute sulphuric acid, ½ fl. oz.; water, 1 pint: to be added to 30 gallons of water. *A sulphur vapour bath* may be prepared by evaporating ½ oz. to 2 oz. of the solution of lime and sulphur by means of a spirit lamp placed under a suitable arrangement of chair, coverings, etc.; the face should be protected from the vapour (Med. Times, i., 1870, p. 308).

ADULTERATIONS.—The precipitated sulphur commonly sold, especially before the passing of the Adulteration Act, contained a large proportion of sulphate of lime; this was due to the employment of sulphuric acid instead of the hydrochloric acid ordered in the Pharmacopœia, but as some excuse, it may be mentioned that a former London Pharmacopœia contained a preparation made with sulphuric acid, and known as "milk of sulphur." This name has now been transferred as a synonym to the modern "precipitated sulphur," and hence has arisen much confusion and even litigation. Druggists have been prosecuted for supplying the lime compound when asked for "milk of sulphur," and although convicted by some magistrates of offences against the Act, the convictions have mostly been quashed on appeal to a higher court, on the ground that "milk of sulphur" is known by trade custom to be a distinct thing from the pure precipitated form. It is desirable that this should be particularly understood (B. M. J., i., 1877; Lancet, i., 1876, p. 936). As a rule, a pure preparation may be obtained by asking for that of the B.P. An adulterated specimen is whiter, with only slight yellowish tinge, and when pressed looks silky and glistening: under the microscope, crystals may be seen in thin tables or elongated prisms, and on exposure to a red heat, lime is left as a white ash (Med. Times, i., 1853). Washed Sicilian sulphur is nearly always pure, but that prepared from pyrites often contains arsenic.

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PHOSPHORUS, P, = 31.

This non-metallic element was obtained in the seventeenth century from the urinary phosphates by German chemists, and by Dr. Boyle in this country. London was, for some time, the principal place of its manufacture, so that it became known as "phosphorus anglicanus." It occurs, variously combined, in certain especially fertile soils, in the seeds of vegetables, and in the nerve-tissue and bone of animals (particularly when young), as well as in the blood and the urine.

PREPARATION.—It is now procured from bone-ash (os ustum) by digesting it in sulphuric acid, and then distilling with charcoal.

The contained phosphate of lime is partially changed into superphosphate and metaphosphate: phosphorus distils over, and, by a further process of purifying, is obtained as a colourless, oily liquid, which solidifies in cakes, or in rounded hollow pencils, according to the shape of the glass moulds employed. The last part of the process may be represented thus: $3Ca(PO_3)_2 + 10C = 4P + Ca_3(PO_4)_2 + 10CO$.

CHARACTERS.—The cakes or pencils are colourless, waxy, and translucent when fresh, but on exposure become coated with an opaque layer of crystals, which may be white, yellowish, or sometimes red from the formation of an allotropic variety of phosphorus. Phosphorus inflames so easily that it needs to be kept under cold water, in which it is practically insoluble; in ether, turpentine, and oils it is soluble to a great extent; in rectified spirit it is but slightly so (1 part in 320); in chloroform, 1 per cent.; but in bisulphide of carbon it is wholly soluble. ("Fenian fire" is the term given to a very inflammable solution in this liquid, containing 70 per cent.) Naunyn states that phosphorus is very slightly soluble in water at 96° to 104° F.; it is more soluble in organic fluids. The element is soft and flexible at ordinary temperatures, melts at 110°, and takes fire at a little over that point; it is luminous in the dark, and, when

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exposed to air, gives off white vapours of phosphorous acid, exhaling an odour *sui generis*, which has been compared to that of garlic.

On exposure to sunlight or to heat in closed vessels, it is converted into red or "amorphous" phosphorus—a brittle powder which is not acted on by the air, and is insoluble; when volatilized, this reverts to the ordinary form.

Amorphous phosphorus has been, by some observers, credited with physiological activity. Thus, Bednar used it for a long period in small doses, and observed symptoms of excitation, trembling, and clonic convulsions; but as much as 1 oz. has been given to dogs without perceptible effect. Thompson, in twelve carefully-observed cases, found its action *nil*, and plausibly attributes its supposed powers to a slight amount of contained ordinary phosphorus (Pharm. Journ., July, 1875). I believe it to be practically inert, and the following observations will refer only to the ordinary form.

Zinci Phosphidum—Phosphide of Zinc, PZn_3 (not officinal). A greyish friable substance, having a lustrous crystalline fracture, stable at ordinary temperatures, readily decomposed by weak acids, almost tasteless, but possessing active properties like those of phosphorus.

ABSORPTION AND ELIMINATION.—Phosphorus taken by the mouth, and especially when finely divided or dissolved, is absorbed into the blood under the influence of alkaline, albuminoid, or oleaginous materials with which it meets in the stomach and intestine: the amount and the rapidity of its absorption are proportionate to the amount of such materials, and especially of fats, which are its *best* solvents. The exact condition in which it circulates is still a subject for discussion; according to varying circumstances some portion may pass into the blood *unaltered* (Orfila, etc.), another oxidized, as hypophosphorous, phosphorous, or phosphoric acid (Frerichs, Munk and Leyden, etc.), and a third portion as phosphuretted hydrogen (Lecorché, Archives de Physiologie, 1-2). It has been found in each of these forms in certain cases of poisoning, though in other cases none at all has been detected.

Portions of unabsorbed phosphorus pass sometimes with the

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fæces, rendering them phosphorescent, and the urine has presented a similar appearance: the element has also been found in a free state in the liver, ten hours after death (Dybkowsky) —it is eliminated by it, and by the other glandular organs, by the skin, and by the lungs.

PHYSIOLOGICAL ACTION.—*External.*—When applied in substance phosphorus has been known to inflame on the skin, and, indeed, has been used as a moxa; it is liable to cause very troublesome sores and even gangrene, and the same results may follow its use in ointment. In certain experiments on *dogs*, however, when pieces of the element were placed in the cellular tissue they remained unaltered as to size and translucency, and no inflammation was excited, yet the animals are said to have died in a few weeks from phosphorus poisoning; whilst, on the other hand, rabbits and some other animals treated in the same way did not show either local or general symptoms. Trasbot records a curious circumstance—a dog swallowed a stick of phosphorus, and no symptoms of local irritation appeared, and afterwards it was found in an abscess as an ordinary foreign body might have been. It is not easy to draw definite conclusions from such experiments, other than that pure phosphorus does not necessarily act as a local irritant (Ranvier, Gaz. Med., 1867; Archives Gén., 1868). Phosphorus vapour causes irritation, catarrh, and even inflammation of mucous membranes with which it comes in contact, especially the conjunctival and respiratory membranes; it has also a special effect in causing inflammation of the *periosteum* and *bone* with necrosis of exposed parts such as the maxilla and teeth. It is only when the phosphorus vapour *directly* reaches the periosteum or some raw vascular surface in immediate connection with the nutrition of bone, and when its application is prolonged under particular circumstances of temperature, and probably of oxidation, that its injurious effects are witnessed. Thus it is, when there are carious teeth in the jaw, and the fumes can act directly on the exposed dental pulp, that necrosis occurs, and it is noteworthy that not until eleven years after the opening of the match factory in Vienna was the first case of this kind seen, and only those engaged in "dipping and drying" the matches were affected.

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The disease is more common in the lower jaw, but not rare in the upper, and it has also attacked the palate and frontal bones. The general health of the workers previous to the necrosis or buccal inflammation is, with the exception of pulmonary catarrh, remarkably good.

PHYSIOLOGICAL ACTION.—*Internal.*—Digestive System.—After taking, in ethereal tincture, $\frac{1}{50}$ gr. each morning for ten days, and then $\frac{1}{100}$ gr. for nearly four weeks, I experienced increased thirst and dryness of mouth, with coated tongue, flatulent distension and eructation, and uneasy feeling in the region of the gall-bladder, without nausea or vomiting; the motions were dark but healthy, the urine natural. There was slight headache and sense of fulness along the vertex and over the left temple, with increased restlessness and sleeplessness. On discontinuing the medicine, these symptoms disappeared in about three days, and on resuming it at the end of a month I felt them return in about ten days time. Other persons may take the quantity just mentioned without so much inconvenience, but larger doses ($\frac{1}{30}$ to $\frac{1}{15}$ gr. and upwards) are very liable to disorder the stomach, causing nausea, and a sense of warmth or irritation. The appetite may be at first increased, but in many patients dyspepsia quickly occurs, and nausea, flatulence, colic, or diarrhœa hinders the employment of at least the ordinary preparations of phosphorus. A silvery-white condition of the tongue may be caused, and the gums may become inflamed. *Zinc phosphide* in any quantity above $\frac{1}{4}$ gr. readily induces vomiting.

Professor Gubler, examining the effects of this phosphide upon artificial digestion, found that the phosphuretted hydrogen which was developed arrested the process, and he concluded that the same thing occurred with other preparations of phosphorus taken by the stomach: whilst Dr. A. Thompson attributes gastric irritation to the formation of hypophosphorous acid, and states that he has only seen these symptoms occur after the use of mixtures prepared with a *vegetable* oil.

Whatever the precise explanation may be, the limit of medicinal and the commencement of toxic doses is marked by more evident irritation of the digestive organs—the mouth becomes tender and sore, the nausea is accompanied with

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retching, vomiting, and diarrhœa; tenderness and enlargement of the liver may be detected, and there is an icteric tint of skin and conjunctivæ. In the irritant form of phosphorus-poisoning (to be described separately), these symptoms become very severe.

Cutaneous System—Mucous Membrane.—A good deal of irritation with hyperæsthesia may be determined in the skin and the conjunctivæ, as well as in the buccal membrane, by the use of phosphorus. It is not easy to say whether this is caused by the elimination of the drug, or by the presence of biliary compounds from altered liver-function, or from impaired blood-condition: the icteric tint has been already mentioned. In cases of poisoning, erythematous and hæmorrhagic patches occur in the skin: and increased perspiration has been traced to the medicinal use of the drug.

Genito-urinary System.—There is but little evidence of any stimulus to the generative function or organs exerted by phosphorus given to healthy subjects, whatever may be its power in certain forms of disease. The stimulation that has been noted in some cases, both of men and animals, was not *special*, but merely a part of the *general* stimulus to the whole nervous system. Leroy, indeed, and some other French authors, have reported some temporary genital stimulation from large doses, and in a few cases of poisoning, irritation and excitement of the genitalia have been recorded, but they are to be explained as above. Thompson gave to two healthy adults 1 to 1½ gr. of zinc phosphide daily for eight or nine days, and to another ⅛ to ¼ gr. of free phosphorus until symptoms of incipient poisoning arose, but without any trace of aphrodisiac effect. Dr. Eames has reported similar negative results from observations with phosphuretted oil, and Mr. Bradley's experience is to the same effect.

With special reference to this point, I have myself carefully experimented upon twenty healthy men. Ten of them took $\frac{1}{10}$ gr. daily for a fortnight; five took ⅛ gr. each day for a similar period; and the other five took ½ gr. every third day for five successive doses. Toxic symptoms occurred in some of the subjects, but, except possibly in one of the last set, no sign or feeling of increased sexual

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excitement was observed. I have, however, seen men from forty to sixty years of age, apparently in good health, but suffering from complete loss of generative power (in consequence either of previous sexual abuse, or of over-taxed brain and nervous system), in whom very small doses—$\frac{1}{100}$ gr. thrice daily—caused weak erections and involuntary emissions, but mental depression was developed to such an extent as to compel the suspension of the drug; this implies a state of irritation, but certainly not one of increased tone or strength.

With regard to its influence upon the *uterus*, we have evidence that long-suppressed menstruation may reappear under its continued use in small doses, but this may reasonably be connected with improvement in the blood-condition rather than with specific stimulation: in cases of poisoning, however, uterine hæmorrhage and abortion occur (*v.* p. 53).

The urine under the influence of phosphorus becomes high coloured and loaded, sometimes phosphorescent, and with a smell of violets or of sulphur.

Husemann reports the nitrogenous constituents increased in amount, and more recently in dogs poisoned by phosphorus Bauer found the excretion of urea notably increased—20 to 90 per cent. above normal (Zeitsch. f. Biol., Bd. xiv., Hft. 4, 1878); the phosphates are unaltered in quantity (Derlon). Leucin, tyrosin, and paralactic acid have been found in cases of poisoning.

Osseous System.—Wegner has furnished definite proof that phosphorus stimulates the growth of true bone, for after giving minute doses continuously to animals, he found the epiphyseal cartilages ossify more quickly and more completely than usual, and the cancellous and compact bone become more dense, even to the extent of obliterating the medullary canal (Virchow's Archiv, June 22, 1872). Exostoses commonly form in cattle feeding near the bone works at Swansea, and have been plausibly traced to phosphorus fumes in the surrounding atmosphere (Stanley on Bones, Med. Times, 1854), and although we find clinically that inflammation and necrosis follow the direct local irritation of strong phosphorus vapour, yet even in such cases exostoses commonly form in another part of the same bone.

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Nervous System.—The fact just recorded of phosphorus stimulating the growth of bone—a tissue of which it forms a component part—has led to the inference that it can stimulate the nutrition of nerve-tissue, of which also it forms a normal constituent; but the evidence on this subject is rather clinical than experimental. Gubler describes the effect of $\frac{1}{30}$ to $\frac{1}{15}$ gr. to be a "general sense of stimulation more complete than that caused by coffee, more active than that produced by opium." A. Thompson speaks of it as producing "exhilaration, and increased capacity for exertion, both mental and physical, and an effect like that of alcohol without the subsequent depression." He states also that if $\frac{1}{2}$ to 1 gr. be taken in the course of twenty-four hours, the feelings described are more sustained, and transient giddiness or quasi intoxication occurs. There seems to me some exaggeration in these accounts, but it is within my own experience that a general tonic effect may be obtained from these and smaller quantities of the drug. In cases where poisonous symptoms are developed, marked excitement, tremor, and spasmodic muscular twitching occur, and in severe cases, cramp or partial paralysis, delirium, convulsion, collapse, or coma.

Circulatory System.—In accordance with the slight general excitation already described, the pulse and temperature are slightly raised about an hour after taking doses of $\frac{1}{30}$ gr.; and after such doses, given daily for some weeks, the circulation has been found more equable and more steady than before (Dr. Ford on fifteen patients, Amer. Journ. Insan., Jan., 1874). Thompson has noted dilatation of the skin-capillaries. In toxic cases the pulse rises to 120 or more per minute, and the temperature to 102° to 103° F., though this condition is only temporary.

Dr. Gowers has proved that under the influence of small continued doses the proportion of red blood-corpuscles is increased (B. M. J., i., 1878), at least in lymphoma, and this interesting observation may throw light on the tonic power of the drug.

TOXIC ACTION.—The poisonous symptoms produced are essentially of irritant and destructive character, but vary in

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degree, and are often obscure and insidious—probably in proportion to the varying amount absorbed, or the chemical changes the drug undergoes under different circumstances. Lecorché makes three forms of "acute phosphorismus": 1, that produced by phosphuretted hydrogen; 2, that by phosphoric acid; 3, a mixed form; but the clinical varieties described by Trousseau, or better by Dr. Guy, are of more practical importance—he names them as 1, the irritant; 2, the nervous; and 3, the hæmorrhagic form—and a brief notice of them comes within the scope of our subject, because it will help to fix in the mind of the reader the characters of the full physiological action of the drug.

1. *The irritant form* is the most common: it is induced (on the Continent, not infrequently) by swallowing match-heads, or a certain rat-poison paste. A foul taste and smell, like garlic or sulphur, are first perceived, then heat and swelling of the tongue and fauces, pain and distension of the stomach, bilious and mucous vomiting and purging, with colic and abdominal tenderness. The ejecta occasionally contain blood, and may be phosphorescent, and the fæces contain small masses of crystals of the fatty acids, and later in the attack, become clay-coloured. The pulse rises to 120 or higher, and the temperature to 102° or 103° F., but this pyrexia passes away as the gastro-intestinal symptoms become very severe, and is succeeded by an opposite condition (Gubler).

In the early stages there is pronounced nerve-excitement, with hyperæsthesia, agitation, talkative delirium, and delusion, which is sometimes of erotic character, though priapism is rare. Muscular twitchings and cramps, and even general convulsions occur, but later on follow prostration, fainting, and collapse, loss of muscular sense, and of sensation, retention of urine, and partial paralysis, affecting mostly the extensor muscles.

2. *In the nervous form*, these latter symptoms become much more marked, but there is little pyrexia; erythematous spots occur in the skin, which is dry and yellow, and later, becomes cold: dilatation of pupil and strabismus are described, and the fatal termination comes on with somnolence and coma.

3. *The hæmorrhagic form* is less quickly fatal than the others. In it, the ejecta are almost wholly sanguineous; bleeding occurs

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in and from the skin and mucous membranes, and many parts of the body. It is due partly to the altered blood-state, and partly to general softening of the tissues, including fatty degeneration of vessels (Lebert). In women there is uterine hæmorrhage, miscarriage, or abortion—but these may be due to the irritant effects on the intestinal canal.

In all cases of phosphorus-poisoning, about the third or fourth day pain is felt over the liver, and is followed shortly afterwards by jaundice, headache, and sleeplessness: the urine is found to contain bile, and generally albumen, leucin, tyrosin, and paralactic acid. The presence of bile is an argument that the jaundice depends not on suppression, but on occlusion of the biliary passages, which is probably catarrhal in character. In exceptional cases (in which, probably, only a small amount of the poison has been absorbed) there has been neither gastro-enteritis, nerve-excitement, nor quick pulse, but the prominent symptoms have been jaundice and hepatic congestion (Brit. and For. Rev., April, 1863). The time that elapses from the taking of the phosphorus to the appearance of symptoms, varies from a few minutes to two days. Death, when it occurs, is usually from asthenia, but the course of the illness is not always steadily progressive: sometimes the severe symptoms subside for a few hours or days, and death takes place *suddenly*, from failure of the cardiac muscle (Habershon, Med.-Chir. Trans., v., 50). A fatal dose may be stated as about 1 to 2 gr. for adults, but much less for children, in whom vomiting and convulsions are usually the prominent symptoms.

TOLERANCE.—The system may become habituated to the use of phosphorus to some extent, and a gradual increase of dose may be borne up to an amount which would not at first be tolerated. In using it for neuralgia, Thompson has found that cases not relieved by a gradually increased dose, have yielded to a similar dose, given *at once* after allowing an interval to elapse. Any "cumulative action," so called, may be explained by the mechanical accumulation of the drug in the stomach or intestines.

PATHOLOGICAL CHANGES INDUCED BY PHOSPHORUS.—Ecchymoses and gangrenous spots have been found in

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the intestinal tract, together with swelling and softening of the mucous membrane and mesenteric glands; rarely perforation. The viscera are hyperæmic, and œdema and hæmorrhagic infiltration affect the skin, serous membranes, and other tissues, especially the mediastinum; hæmorrhage has also occurred between the spinal membranes, thus accounting for a paralysis. The blood itself is black and viscid, and in many cases, even during life, the corpuscles are destroyed and the hæmoglobin altered, so that it will not show the usual spectrum (Lecorché, Voit, etc.); in others, the corpuscles have been found normal after death, and the blood-crystals (of hæmoglobin and hæmato-crystalline) found unchanged (Lebert, Gubler); but in all cases the blood and the solid organs contain an increased proportion of waste products, such as urea, creatin, leucin, tyrosin, etc., and fatty degeneration affects every tissue. The muscles, including the cardiac muscle, are discoloured, soft, and fatty, the capillary walls are degenerated in a similar manner, the gastric glands and renal tubules are choked with fatty epithelium, and the liver especially is enlarged, yellow in colour, and its cells filled with fat-globules—in protracted cases, cell-atrophy occurs.

The condition described resembles closely that found in an idiopathic malady, "acute yellow atrophy," of the liver, and the question of diagnosis has been raised in medico-legal cases (Annales d'Hygiène, Jan., 1869). An illustration is recorded by Surgeon-Major Martin, in a man admitted to Netley Hospital without any history of poison, and whose case was diagnosed as acute yellow atrophy—it was only after death that the real fact of phosphorus-poisoning was disclosed by examination (B. M. J., i., 1878).

THEORY OF ACTION.—The direct irritant effects on the intestinal canal depend rather upon the oxygen—or hydrogen—compounds formed, than upon phosphorus itself,—and the pain, vomiting, prostration, etc., follow from the local irritation produced, just as with other corrosive poisons.

To explain the other constitutional symptoms, and the subsequent arrest of nutrition and fatty degeneration, several modern writers have argued that the strong affinity of phos-

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phorus for oxygen leads it to abstract that vital gas from the blood, and so induce a condition of *asphyxia* (Eulenburg, Lecorché), but as oxygen would be continually renewed by inspiration, and the amount that can be absorbed by the metalloid is only limited, I cannot see that such serious consequences would result; neither would asphyxia produce preliminary excitement nor subsequent waste, nor is the blood of poisoned animals *always* found black; it is sometimes red, a condition incompatible with asphyxia (Vigier, Bulletin, 1868). Others have argued that phosphorus indeed removes oxygen from the blood and the tissues, but with the main result of forming phosphorous and phosphoric acids, which act as *local* corrosive agents, and which, after absorption, destroy blood-corpuscles. The stomach contains some free oxygen, especially after food (Chevreul), and it has been suggested that when the drug is taken under circumstances which favour its retention in the stomach, and its oxidation there, then gastro-intestinal troubles are the most marked (*irritant* form of poisoning). That phosphoric acid is formed in the system seems proved by its excretion from the lungs, and further, it is pointed out that this acid, when injected into the veins, will destroy the corpuscles, and will lead to fatty degeneration (Personne); and although it will not act thus when given by the mouth, yet it may do so when directly generated within the system by the oxidation of free phosphorus. Whilst allowing this to some extent, I cannot believe it possible that a sufficient amount to account for such results could be formed in this manner. Again, oxygen has proved an antidote to phosphorus-poisoning (Crocq), and turpentine acts as an antidote by a process of oxidation, whilst free ventilation is the best means of preventing necrosis of the maxilla, etc., in phosphorus factories (Savory, Sieveking), so that it seems at least unlikely that *oxidation* of phosphorus is the cause of its ill effects.

In explaining the action of the drug I incline to accept the theory of Gubler, who suggests that it acts chiefly by the strong *ozonising* power which we know burning phosphorus to possess. Although through this combustion a minimum quantity of oxygen gets lost for the respiration, the remainder would shortly acquire from its admixture with the ozonized portion so great

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an increase in combustion power as to be very likely to induce general stimulation of the system. But increased activity is accompanied by an increased waste, particularly of the blood-cells; anæmia follows this irregular activity, and fatty degeneration of the tissues and impairment in the function of the different organs take place. On the other hand, amorphous phosphorus, which has no ozonizing power, would fail to produce any such symptoms, as is really the case; but more accurate analyses of the secretions are required in order to support this hypothesis. The excretion of carbonic acid is said to be lessened (Rabuteau)—we should not expect this unless in advanced stages; as already stated, nitrogenous excretions are increased in amount, whilst the urinary phosphates remain about normal.

I have still to refer to the effects of *Phosphuretted Hydrogen*, which would readily be formed from water and phosphorus, or from any phosphides, or from the very unstable hypophosphorous acid. We have seen that this gas interferes with the digestive process, and we know that if it be passed into defibrinated blood, it turns it black and destroys its hæmoglobin (Dybkowsky); also that it possesses, equally with phosphoric acid, and other acids and substances which act destructively on the blood, the power of inducing fatty degeneration from impaired nutrition (Bence Jones and others, Med. Times, ii., 1865, p. 593). The formation of phosphuretted hydrogen in the system would equally well explain the production of the principal toxic effects of free phosphorus, and I incline to attribute them largely to it. Lecorché states that this compound has been found in the tissues in fatal cases, and he connects its presence specially with the second or neurotic form of poisoning, in which the course is rapid and nerve-symptoms are prominent.

Fatty degeneration was found by Munk and Leyden in the tissues of frogs and rabbits within two or three days after giving phosphorus (Med. Times, ii., 1865, p. 593), and since these researches its occurrence in phosphorus-poisoning has been amply demonstrated, especially by German observers (v. Naunyn in Ziemssen's Cyclopædia).

In Tamassia's experiments it was very rapidly produced. He injected 3, 4, 5, 6 gr. respectively into the rectum of four animals (dogs and rabbits); toxic symptoms occurred in about

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fifteen minutes, death in eight hours (the temperature falling 8° F.). In all four of the animals the kidneys, and in two of them the liver also, were in a state of fatty degeneration (Med. Record, Jan., 1878).

SYNERGISTS. — Arsenic is allied to phosphorus in its power of acting upon the blood (with advantage in small doses, in large doses with destructive effect), also in its action upon nutrition. Cantharides, oxygen, and stimulants have somewhat analogous stimulating powers. It is a curious speculation that ergot of rye owes its properties to the phosphoric acid it contains (Levi, Brit. and For. Rev., April, 1876).

Adjuvants are found in phosphoric acid, and in fatty and fleshy foods. Phosphoric acid has especially been shown to develop or augment the powers of phosphorus, probably from aiding in its solution and circulation (Personne). The brains of animals and the flesh of hogs are said to be rich in phosphorus, and *roast* food to retain more than *boiled*.

ANTAGONISTS—ANTIDOTES.—Hydrate of magnesia, or of lime, will neutralize the acid compounds of phosphorus, and carbon will absorb phosphorus vapour. Sulphide of carbon antagonizes the excitant action of the drug, as also do sulphuretted hydrogen, anæsthetics generally, and cyanides (Gubler). Nitrate of silver was recommended as antidotal by Bellini (Med.-Chir. Rev., ii., 1875).

In an important experiment by Crocq, oxygen was used as an antidote, defibrinated blood charged with the gas being injected into the veins, with the effect of restoring to its normal condition the dark, pitch-like blood of poisoned animals (Brit. and For. Rev., ii., 1875).

But the two antidotes which claim special attention are sulphate of copper and oil of turpentine. With any soluble salt of copper, phosphorus forms a black phosphide, non-poisonous; and as copper sulphate is also a good emetic, it is specially available for cases when the poison has been taken by the stomach, and when the remedy can be given soon afterwards. Five grains should be given every two or three minutes until free vomiting is induced, and then, either continued in smaller doses and with opium, or turpentine may be substituted.

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If oil of turpentine be brought into contact with phosphorus at a suitable temperature, a crystalline white solid is formed—terebinthino-phosphorus acid—which is not poisonous. Kohler and Schimpf obtained it by adding gradually 2 lbs. of the oil to ¾ oz. of the element at 40° C., and the same substance has been obtained in the distillate from urine in cases of poisoning (Pharm. Journ., March, 1873). To produce the desired result, the oil must come into *direct* contact with phosphorus in the stomach, and in the proportion of about 100 parts to each one of the latter. Eleven hours is the longest time that has elapsed before the administration of the remedy in successful cases. Moreover, it is not every kind that will act well; the pure rectified oil, and much of that imported as German and American, do not form the crystalline acid, and hence a difference in the results of some observers. It is the crude, acid, French oil, or that which has been ozonized by long exposure, which gives reliable results. It is said also that milk lessens its good effect.

A case illustrating the value of both the antidotes recommended occurred in my practice some years ago. A young man (insane from over-study for examination) swallowed some pieces of solid phosphorus, and whilst his friends were gone for assistance, gashed his throat and body with a razor. When I saw him the most pressing need was to stay hæmorrhage, and whilst doing this I sent for some copper sulphate and turpentine, giving him at once mustard and water. This and the copper produced good emesis, with rejection of a piece of phosphorus two inches long. I then began giving turpentine in milk (also in water), but still encouraged vomiting, because from the small pieces left in the patient's bottle of phosphorus more was thought to have been taken. Eventually two other pieces, 1½ in. and ½ in. long, were rejected, after having been in the stomach at least three hours. Several more doses of turpentine were given, and the patient made a good recovery with the exception of some dyspepsia: he was seen afterwards by Dr. Fuller, the family physician, and passed from under my care, but is, I believe, still living in an asylum. The case may be considered another illustration of the fact that large pieces of phosphorus are less dangerous than the finely-divided

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substance, but I think real benefit resulted from the antidotes used.

A case is reported of a man who swallowed 120 match-heads, and then took turpentine to increase the effect. He did not vomit but recovered (Med.-Chir. Rev., ii., 1869, p. 555).

Other cases, cured by the same antidotes, are given in Braithwaite, i., 1872, p. 131, and in Syd. Soc. Year Books, and B. M. J., i., 1878.

THERAPEUTICAL ACTION.—*Internal.*—From what has preceded it will be recognized that the value of phosphorus lies in its power of strengthening and giving tone to the nervous centres when their activity is impaired; also, since nerve-debility is a cause of many other besides what are called *nervous diseases*, a nerve-tonic of this kind has a wide field of usefulness, and is applicable not only in nerve-exhaustion and pain, but in many conditions of adynamia. Rabuteau, however, states an opposite view when he says: "I do not hesitate to assert that this poison has never cured anything up to the present time, and I would never prescribe it, it has always been useless" (Elements, p. 211); whilst Beaumetz, A. Thompson, and others have recorded wonderful results from it. The truth probably lies between the two extremes, and we must not forget that some failures may be accounted for by inactive preparations of a drug always difficult to dispense.

Neuralgia.—Eighty years ago von Lobel, a physician, related his cure from an inveterate cranial neuralgia (which was accompanied with debility and failure of mental and sensory power) by an ethereal solution of the drug. He took ¼ gr. every two hours, and (with one relapse) was restored to health in a short time, and after only a few doses. This experience was corroborated to some extent, and the remedy came into great repute, but was soon found to be a dangerous one and difficult to manage, and it gradually fell into disuse, no doubt owing to the largeness of the doses. A few years ago Mr. M. Bradley published a case of neuralgia of the chest-walls, rapidly cured by "tincture of phosphorus," after failure of all recognized remedies, and later he recorded other successful results (B. M. J., Oct., 1872). In the following year

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Dr. Slade King added testimony to its value in doses of $\frac{1}{30}$ to $\frac{1}{60}$ gr. (Med. Times), and Dr. Ashburton Thompson recorded forty consecutive cases either cured or relieved (Practitioner, 1873); Mr. Sanger, of Alfriston, referred to an equal number (B. M. J.), and Dr. Hammond praised it in America (Practitioner, i., 1877).

Drs. Radcliffe and Broadbent may be cited also amongst those who early employed it with good results, the latter especially in "anginoid pain"—a *cardiac* neuralgia (Practitioner, 1875). It was found useful in cases connected with extreme general debility — whether from over-lactation, hæmorrhage, or simple asthenia—in cases due to pregnancy, to cold, and to local irritation, such as carious teeth, and even to rectal cancer (Thompson). Anstie's experience was not so favourable.

I have myself seen much benefit from it in many of the above cases, also in *uterine neuralgia* occurring in sensitive patients, and induced either by protracted lactation, excessive sexual passion, or by mental or local causes. The severe pain is apt to come on just before or during the monthly period, and then $\frac{1}{100}$ to $\frac{1}{30}$ gr. should be given three or four times daily; during the interval the smaller dose should be given, and less frequently.

Intercostal Neuralgia. — For upwards of twenty years I have been accustomed to use phosphorus in this affection, and can speak favourably of its power. I have notes of fifty-six cases wherein the pain quickly subsided under this treatment, and did not, so far as I know, subsequently return. In some instances phosphorus succeeded where arsenic had quite failed. The dose was $\frac{1}{100}$ to $\frac{1}{30}$ gr. three times daily.

With regard to the dose of phosphorus in neuralgia and nerve-disorders generally, I may say that in my experience the comparatively large doses recommended by Dr. A. Thompson cannot be tolerated for any length of time by the system. They may seem at first to stimulate, or rather *over*-stimulate, the nerve-centres, but after a short time they depress in a disastrous manner; whilst the small doses of $\frac{1}{600}$ to $\frac{1}{30}$ gr., continued for due time, nourish and strengthen nerve-tissue, without any evidence of undue excitement. A therapeutical and *not* a physiological action is to be always desired.

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Herpes Zoster. — In this affection, which is distinctly neurotic, I have found good from phosphorus, for it has in some instances quickly relieved the severe pain.

Facial Spasm.—Twitching of the facial muscles, especially about the orbit, often occurs in cases of neuralgia and of impaired nerve-power. I have known it markedly improved by phosphorus.

Nerve-Exhaustion.—Gubler found phosphide of zinc remove the sensation of fatigue after hard work, improve appetite and digestion, and conduce to sleep. He gave a ½-gr. dose with an ordinary digestive pill at dinner time, but such a dose is too large, and is very liable to nauseate. When the nervous system is jaded and below par, so that slight impressions are too deeply felt, and the nerve-controlling power is impaired, phosphorus has been found to supply what is wanting for a time; also, it has been said to improve intellectual tone in those subjected to either monotonous brain-work or to an unusual mental effort (Thompson). Dr. Broadbent early recorded some striking cases of this kind—one of "nervous break-down" in a city merchant, with insomnia, and extreme depression and incapacity for work, and another in which "epileptiform vertigo" was present in addition. Both got well "quickly and completely" under phosphorus (Practitioner, 1873).

In cases of **Chronic Exhaustion of Brain-power**, or of general nerve-exhaustion consequent on chronic disease, small doses continued for a long time are advisable, and have been plausibly held to supply to the nerve-tissue a vital element in which it is deficient, and to improve its nutrition, just as Wegner showed that the drug improved the nutrition of bone; and certainly its supply, in some form, to nerve-tissue is as necessary as that of iron to blood-corpuscles.

I have reason to believe that benefit may be obtained from phosphorus even when there exists evidence of atrophic change in the brain, of the nature of white softening or chronic fatty degeneration, with such symptoms as failure of memory and of self-control, loss of proper sensation and cerebral power generally. These are commonly associated with feeble heart-action, and with arterial degeneration, and may occur not only in advanced life, but as a consequence of wasting disease,

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chronic alcoholism, etc. I remember well a case of this kind in which epistaxis was a frequent symptom, and had proved rebellious to iron, acids, and other ordinary treatment in the hands of experienced men: small doses of phosphorus (ethereal tincture) improved the patient very much both as to brain and muscular power, but the symptoms always tended to recur on omission of the remedy, and he continued it for a long time with good results. A suitable dose is $\frac{1}{50}$ gr. thrice daily for about a fortnight, and then it should be reduced to $\frac{1}{100}$ gr. or less, and should be taken for twelve to eighteen months, omission being made for about ten days in each month.

Although I do not find this experience to be general, yet it is not wholly singular, for Dr. Hammond also speaks of the value of the remedy in conditions of softening; he recommends similar doses given with cod-liver oil, or zinc phosphide in $\frac{1}{100}$-gr. doses.

Fatty Degeneration.—That a different action may be obtained from a different dose of the same medicine is an elementary therapeutical axiom in constant application, and it is, I believe, a clinical fact that phosphorus can relieve the symptoms which are usually associated with fatty degeneration, not only of the brain, but of other organs. I have notes of more than thirty cases in which fatty degeneration of the heart might fairly be diagnosed—the cardiac sounds were feeble, the impulse weak, the pulse slow, sometimes excited, irregular, soft, and compressible; with dyspnœa on exertion, and a sense of anxiety and tendency to syncope to a greater or less degree; arcus senilis sometimes present. After taking phosphorus for a few months most of the patients were much relieved, and were able to move about without fear, and with comparative comfort. No doubt somewhat similar cardiac symptoms may be caused by nerve-exhaustion or gout; the absolute diagnosis of fatty degeneration cannot always be insisted on, and I do not wish to maintain that phosphorus reconstructs degenerate cells, but its acknowledged power over nutrition makes it reasonable to suppose that it can hinder or stop commencing degeneration, and especially improve the condition of the nervous system.

It is highly important to carefully proportion the dose to the necessities of each individual case, as some will take with

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advantage more than others. Where the heart-action has been very irregular, or the dyspnœa and syncopal feelings more than ordinarily troublesome, I have given $\frac{1}{30}$ to $\frac{1}{20}$ gr. occasionally, but these doses should not be given frequently for fear of aggravating the symptoms. I prefer to give $\frac{1}{200}$ to $\frac{1}{100}$ or $\frac{1}{50}$ gr. twice or thrice daily. Not only in heart-disease of the kind described, but in fatty degeneration of other organs, and in the form which threatens during typhus and some other acute diseases, phosphorus is worthy of attention.

For many years I have been accustomed to use it in such cases, and the improvement traceable to it is often remarkable. The smaller doses mentioned are to be preferred, in order to avoid irritant effects, and to get the system slowly but more fully under the influence of the remedy; when this is done the effect is more thorough and lasting.

Exhaustion of Fevers, etc.—The value of phosphorus in conditions of extreme exhaustion in advanced disease is one of the earliest recorded experiences of Kramer, Mentz, Leroy, etc. (1733–1798). They used it in the muttering delirium and incipient coma of typhus, the collapse of malignant "bilious fever," and the profound depression of extensive pneumonia. Bayle says, "in every disease where death is imminent from failure of vital force without much structural alteration, phosphorus is indicated. We see this in severe continuous fevers during their last stage, whether they be caused by some miasm, typhus, plague, etc., or by 'spontaneous alteration of the blood,' as in adynamic or putrid fevers (so called); in such cases phosphorus reanimates vitality, furnishes nature the means of effectually resisting the disease, and eliminating its material causes by natural excretory outlets. It is indicated, secondly, in all acute exanthemata when eruption has disappeared suddenly, with aggravation of symptoms (measles, variola, erysipelas, low fever with exanthem); thirdly, in malignant pustule, where the disease has reached its acme and the vital power is almost extinct." Bayle adds that it is useful in chronic gout and rheumatism (which are relieved through profuse excretion of sweat or urine), and "all morbid conditions wherein it is proper to excite these secretions, and at the same time to stimulate vitality in a speedy and energetic manner" (Bibliot. de Thérap., vol. ii.).

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Powers so extensive as these have not been accorded to phosphorus by more modern writers, but Mr. Clay has illustrated its value in the collapse of variola (Lancet, ii., 1858, p. 315), and Dr. John Brunton in the adynamia of typhus and typhoid fevers; rapid improvement taking place under drachm-doses of the following solution:—Tinct. Phosph. Æth. (gr. ½ ad ʒj.) ʒiij., Spt. Vini Rectif. ℥ss., Glycerini ad ℥iss. About two grains were taken in the course of two days.

I have frequently prescribed phosphorus in the exhaustion of typhus and typhoid, and have sometimes seen remarkably good results from it; but, on the other hand, have been often disappointed, and cannot but consider it an uncertain remedy in such cases. I would place more dependence upon ammonia, camphor, and other stimulants of that class, but if they failed, should then have recourse to phosphorus. Another use of the drug in fevers is to assist development of the specific eruption, *e.g.*, in enteric, scarlet fever, and measles, and within my own experience it has proved of service when the eruption has disappeared suddenly with the onset of serious symptoms.

Exhaustion of Generative System—Impotence.—In such conditions phosphorus has long had a reputation, and was much valued by early authorities, but modern experience has limited its powers. If the special exhaustion referred to be only part of a generally enfeebled state, it will doubtless improve as general tone and vigour improve, but this system is not to be stimulated apart from the others; indeed, if it were so, this might be a serious drawback to the ordinary use of the remedy. I may say, however, that in some of my own cases an irritable weakly condition of the sexual organs, traceable to previous early abuses or subsequent excesses, has been much benefited by steadily continued doses of $\frac{1}{100}$ to $\frac{1}{100}$ gr. thrice daily.

Spinal Irritation.—I consider phosphorus of greater value when this condition is connected with onanism than when arising from over-fatigue or other causes. The irritation is marked by local discomfort, a burning pain in the lumbar region, sense of fatigue and impaired walking power, mental distress, etc. In such cases it is essential that the patient exert moral control over himself, and that treatment be continued judiciously for

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some months. The remedy relieves the spinal pain and the mental depression, and thus indirectly tends to lessen abnormal sexual desire.

Disorders of Menstruation.—Patients with scanty, watery, and irregular catamenia, sometimes suffer, about the time of the periods, from sick headache, and when this is the case a continued course of phosphorus increases the quantity and improves the quality and regularity of the menses, and the headaches frequently disappear. Phosphorus, like aconite, restores the discharge when suddenly interrupted by cold or fright.

When the discharge is not only too profuse but watery in character, and rather delayed beyond the natural time, phosphorus is of considerable use, as it checks the overflow, relieves the back-ache, improves the mental depression, removes the nausea and vomiting so frequently attendant, and strengthens the general condition. It is also useful in profuse menstruation attended with excessive sexual excitement. The dose should rarely exceed $\frac{1}{100}$ gr. every two to four hours during the menses, and morning and night during the menopause.

Paralysis.—Cases of hemiplegia relieved by phosphorus are on record, but not from very reliable sources. It is contra-indicated in acute irritative conditions, but in chronic stages should be tried, particularly if exhaustion be a prominent symptom. I agree, generally, with Lemaire, who has summarized the modern use of it for paralysis, and finds that in local palsies after severe illness, or from anæmia or hæmorrhage, it has a general tonic stimulant power, but not a specific curative effect, and is always uncertain. In paralysis dependent on severe organic disease, tumour, or hæmorrhage in the nerve-centres, it cannot, of course, be relied upon, nor in hysterical palsy, although, in the last-named, I have sometimes seen advantage from it, and Dr. Hammond speaks well of a combination of zinc-phosphide with strychnia. It is commonly useless in old paraplegia, in sclerosis, and in lead palsy; and Mr. Sanger is almost alone in reporting paraplegia and paralysis agitans cured by the drug. I have, however, known it relieve formication in paralysed parts. It has been found of service in recent ataxy and in mercurial palsy (tremor), and its advantage has been distinct in *functional derangement with adynamia*, and in

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some slight structural lesions when inflammation, fever, and cerebral excitement were absent (Bulletin Gén. de Thérap., Sept., 1875). The dose recommended is about one milligramme ($\frac{1}{65}$ gr.). For intra-ocular paralysis it was used by Tavignot, externally and internally.

Tremor.—In alcoholic tremor, as well as in the mercurial form, and in partial paralysis of the same kind caused by arsenic, Dr. G. De Mussy has found advantage from four-milligramme doses ($\frac{1}{16}$ gr.) (Lancet, i., 1876).

Locomotor Ataxy.—Dujardin Beaumetz has advocated the use of phosphorus in ataxia, upon the strength of four partially successful cases, of which, however, the after-history is not given. His favourable observations have not been generally confirmed, though a patient said to be suffering from "progressive locomotor ataxy," unrelieved by bromides, strychnia, quinine, and iron, was able to stand and to walk after two months' treatment by phosphuretted oil (Hartley, Lancet, i., 1877), and some other scattered observations may be found. The malady exhibits, in its natural course, remission and improvements, partial, and lasting for a variable time, but sufficient to throw uncertainty on the action of any medicine, unless very carefully and frequently verified This was instanced in one of eighteen cases of ataxy reported by Mr. Bradley (B. M. J., ii., 1878)—the improvement observed might have been credited to the remedy, had not the patient relapsed afterwards, whilst under the same treatment. The others remained *in statu quo*. It is possible that in these and similar instances, the dose was too large, or not continued long enough, and further observations should be made. Certainly, in some few cases I have seen much improvement during a prolonged use of phosphorus ($\frac{1}{100}$ gr.), or zinc phosphide, though I am not satisfied that it was really due to the drug.

Hysteria.—Nerve-power is impaired in this affection, the emotions not being under normal control; more or less neuralgia is often concomitant, and altogether it is a condition in which we should expect phosphorus to be useful, and instances of its value are on record. The cases benefited by it have been acute or chronic, dependent on sudden shock, or gradually coming on with increasing weakness and despondency; in either form a

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period of debility is liable to be followed by convulsive attacks. I do not undervalue moral and hygienic treatment, but amongst medicines, phosphorus in doses of $\frac{1}{100}$ to $\frac{1}{60}$ gr. has proved efficient in my hands. When hysterical attacks are connected with delayed or suppressed menses, pain in iliac and lumbar regions, vomiting, palpitation, and general excitement alternating with depression, I have found this remedy regulate the menstrual periods and cure the hysterical symptoms.

Epilepsy.—In true epilepsy it has, like most other nerve-tonics, been used and commended, but evidence of its really preventing the attacks is contradictory. Broadbent found it useful in epileptiform vertigo (Practitioner, viii.—x.), and Anstie observed it relieve the depression of epileptics and improve their temper and power of control (Med. Times, i., 1862). In the early period of the disease when dependent upon sexual abuse, I have known phosphorus prove very beneficial. I remember especially the cases of two men, aged nineteen and twenty-three, whose attacks began soon after puberty, and who had taken large doses of potassium bromide without evident relief, and who became quite freed from their attacks during a course of phosphorus, and have continued free from them during the four and six years that have since elapsed. The dose was only $\frac{1}{100}$ gr. three times daily, which was continued (irregularly) for twelve or fifteen months.

Melancholia — Dementia. — Dr. S. W. Williams in this country, and Dr. Ford in America, have recorded their experience of phosphorus in these conditions. The six cases of the former physician were treated by $\frac{1}{30}$-gr. doses (Kirby's pills) twice or thrice daily, but only two could be considered relieved (Journal Mental Science, 1874). Dr. Ford recognized improvement in fifteen cases of dementia (Amer. Journ. Insan., Jan., 1874). Dr. Judson Andrews had previously written in favour of *phosphoric acid* in different forms of insanity, but especially those tending to melancholia (Amer. Journ. Insan., Oct., 1869).

I have notes of thirteen cases of recovery from this distressing affection in patients between the ages of thirty-two and forty-five years, most of whom showed well-marked symptoms, such as despondency and depression, suicidal impulse, fear of solitude, loss of sleep, etc.: they looked haggard, with flushed face,

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and complained of cold clammy skin, vertigo, and various disturbances of the digestive system. In addition to general treatment by exercise and different forms of bath and the occasional use of nux vomica or aperients, I gave phosphorus, at first $\frac{1}{30}$ gr., afterwards $\frac{1}{100}$ gr., thrice daily, with the result that all recovered in the course of two to three months. My experience of fourteen other cases between the ages of thirty-five and fifty shows, however, that it is an uncertain remedy, and although quickly beneficial in some cases, in others it is disappointing.

Pneumonia. — A simple pneumonia usually terminates favourably, independently of medicine, and requires at least no active interference, but under certain conditions and complications phosphorus has proved, in my experience, a valuable adjuvant. Thus, if at the commencement of an attack adynamia is very pronounced, this medicine is indicated. It is curious that the most amenable to its action seem to be adult subjects previously robust, and old persons. It is a matter of common observation that the nerve-power fails more rapidly in severe illness attacking such subjects, than it does in the young or the simply delicate. Some degree of biliary disturbance usually accompanies the early stages of pneumonia, and so long as this does not assume a very aggravated form, I have found it a good indication for phosphorus treatment, and especially if prostration be extreme. Again, it is good in ordinary cases with difficult muco-sanguineous expectoration and very marked lowering of strength and evening exacerbations; also in later stages when either pyrexia has subsided and the patient is left very feeble, and does not progress towards convalescence; or again, when red hepatization is complete, fever and prostration increase and suppuration is imminent—although when pus has actually formed, phosphorus is contra-indicated.

Dr. A. Thompson, speaking highly of the value of phosphorus in pneumonia, remarks that success depends much on the dose given, and in his opinion the better results of older practitioners were traceable to their use of full doses, toxic effects being less known and consequently less feared by them. He says, that "no caution need limit the quantity of such a preparation as the tincture, the only limit to be recognized being improvement in the patient." He commonly orders $\frac{1}{12}$-gr. dose in the cases referred

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to, but I cannot agree either with this theory or practice; my best results have been obtained with $\frac{1}{200}$ to $\frac{1}{100}$ or $\frac{1}{50}$ gr. given every two to four hours.

I have also had good results from phosphorus in *chronic* pneumonia; but when it occurs in tuberculous subjects with tendency to hæmorrhage this drug should be avoided. In acute or chronic cases, complicated with *bronchitis*, phosphorus is less appropriate than other remedies.

Chronic Bronchitis.—In simple cases of this affection, when patients complain of a feeling of tension throughout the respiratory tract, and a hacking, dry, and exhausting cough, phosphorus is, however, often valuable.

Pleurisy.—In pleuritis with extensive recurrent effusion of dark bloody-looking serum (as proved by aspiration), in patients whose blood has been impoverished by excessive and long-continued use of stimulants, I have found phosphorus as well as arsenic of much use in hastening absorption of the fluid, and giving tone to the nervous system.

Tuberculous Phthisis.—The action of phosphorus in this affection can only be considered palliative; but it can, at least, moderate some troublesome and irritating symptoms. I have used it in various doses in upwards of 800 cases, of which I have record, and am satisfied that it does not cure advanced tuberculosis, but appears in many cases to arrest its progress, at least for a time, also to improve the condition of the throat and the voice, and to relieve the dry, harassing cough, the pain after food, and even the colliquative diarrhœa and night-sweats. It has also removed pleuritic stitches, and seemed to strengthen the general condition: on the other hand, its use is not free from danger, and requires caution, since it may induce obstinate hæmoptysis where there is a tendency to hæmorrhage.

Chronic Diarrhœa, in children, with frequent watery evacuations, abdominal pains, depression, and emaciation, or the colliquative form, occurring, *e.g.*, in phthisical adults, has often in my hands yielded quickly to phosphorus. Sometimes it is well to give a few doses of Fowler's solution of arsenic in conjunction with phosphorus.

Intestinal Ulceration.—Phosphorus is useful in ulceration of the intestinal mucous membrane, the result of muco-enteritis,

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dysentery, or other causes, and especially when considerable prostration, restlessness, and emaciation are present. It is well, sometimes, to combine it with a course of arsenic.

Chronic Otorrhœa.—In some obstinate cases, common in strumous children, phosphorus is very valuable in stopping the discharge and giving nerve-tone and strength to the system generally. When glycerine of tannin and other astringents fail to permanently stop the discharge, a course of phosphorus, conjoined with the daily application of the tannin, will accomplish a cure.

Cutaneous Diseases.—The value of phosphorus in these maladies was mentioned by Cazenave, and in 1850 Burgess recommended it in psoriasis and in lupus. More recently Dr. Broadbent, inquiring how far the chemical analogies of drugs would guide to their therapeutical effect, was led to use phosphorus in the same class of cases as arsenic, and he recorded six cases of eczema and six of psoriasis treated by the former drug. The majority of these were relieved or cured (Clin. Soc. Trans., vol. iv.).

Dr. Eames also reported successful cases under the same treatment (Dub. Journ., Jan., 1872), and Mr. Squire, recording in detail the course of psoriasis in a young girl, to whom full doses ($\frac{1}{10}$ to $\frac{1}{5}$ gr. per diem) were given for several weeks, concludes that the remedy was of much advantage though not wholly curative by itself (B. M. J., ii., 1877); and it seems to me that in this case more allowance should be made for the change of air and diet, the girl having come from Wales to London.

In a case of Dr. Whipham's, whatever good was obtained in the first month of treatment was lost in the second, and in several cases within my own knowledge—severe and chronic cases, it is true—phosphorus was given without benefit. It would seem, then, that it is *uncertain* as a remedy, and without denying its occasional power of relieving, I think, with Erasmus Wilson, that it is indicated rather for the impaired nerve-condition accompanying many skin-disorders than for any direct influence upon the nutrition of the skin.

Lupus—Scrofuloderma.—In these forms of depraved nutrition theory would suggest that phosphorus might be useful, and

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Dr. Eames states that some cases have recovered under its use in from five to nine months.

Dr. Mackey has given it a fair trial in three or four instances of various forms of lupus, and has found it improve the general condition, but without exerting any special influence over the local affection.

In rodent and cancerous ulceration, however, I have known it relieve the burning and other pains, and also check discharge and lessen exhaustion.

Pemphigus—Acne—Boils.—Cases of cure from each of these disorders under the use of phosphorus have been recorded (B. M. J., ii., 1876). In *pemphigus*, arsenic, as a rule, is to be preferred, and *during an eruption of boils*, phosphorus is only indicated if the pus becomes thin and sanious, and the nerve-power unusually depressed.

A severe case of acne indurata under Dr. Eames seems to have improved remarkably, but the few cases in which I have used it did not derive benefit from it.

Abscess (Fœtid).—In simple cases of abscess, antiseptic surgery, carefully carried out, generally proves successful, but should it not do so, and should the pus become fœtid and watery, and hectic fever appear, with rapid failure of strength, then $\frac{1}{100}$ to $\frac{1}{30}$ gr. phosphorus should be given every two to four hours, and I have seen this produce most favourable results.

Bone-Disease—Rachitis—Fracture.—In cases of fracture, resection, and transplanting of periosteum, Wegner found that small continued doses of phosphorus stimulated the growth of new bone, especially in young animals; also, that ossification in the fœtus was promoted by giving phosphorus to the mother. It is noteworthy that he obtained similar results, though less in degree, from phosphoric acid and oxy-compounds of phosphorus, but not from the amorphous element, nor from lime phosphate.

I have myself seen good results from phosphorus in ordinary *caries* of bone, and again in cases of *abscess* connected with necrosed bone, it lessens suppuration and hastens the separation of the sequestrum; given during pregnancy it relieves the dental caries and neuralgia often incidental to that state,

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and I have given the hypophosphites successfully in such cases. It may be presumed that phosphorus, and such preparations of it, would also improve the nutrition of the fœtus in weakly subjects, and I think they might often be used with advantage in chronic rachitis.

Leucocythæmia — Pernicious Anæmia — Lymphadenoma.—It is in such blood—and gland—disorders, which are essentially of serious, if not fatal import, that phosphorus has been recently employed, and Dr. Broadbent, one of the first to recommend it, offered some evidence in its favour. A boy with "essential anæmia," prostration, diarrhœa, yellow waxy face, etc., recovered very quickly under phosphorus capsules, and remained well for some time. Another case of "leucocythæmia," treated in the same manner, got inflamed spleen, "apparently from very rapid blood-formation" (Practitioner, i., 1875). In a woman with lymphadenoma, having symmetrical enlargement of cervical glands, anæmia, dyspnœa, etc., steadily getting worse for some time, "complete recovery took place," after taking phosphorus (B. M. J., ii., 1876, p. 792). In two other cases—one very far advanced, the other chronic—the same remedy was successful. Some support was given to Dr. Broadbent's conclusions by a case, under Dr. Wilson Fox, of "leukæmia splenica" occurring in a man, aged thirty-seven, in University College Hospital, for when extremely enfeebled he began to take $\frac{1}{50}$ to $\frac{1}{30}$-gr. doses, and after three months' treatment was greatly improved; he died, however, in the following year (Lancet, ii., 1875).

If we add to these cases one of leukæmia (Dr. Gowers), in which the use of phosphorus was followed by diminution in size of glands, and lessened anæmia (though albuminuria and death afterwards occurred), it will be seen that the evidence in favour of phosphorus is not strong, whilst many cases of its failure are on record. Dr. Moxon objects even to receive Dr. Fox's successful case as one of leukæmia, because the white corpuscles in the field were "only twenty to thirty," and refers to about thirty cases of his own ("pernicious anæmia," apparently), all unsuccessfully treated by phosphorus (B. M. J., ii., 1876, p. 792).

At the meetings of the Clinical Society at which this subject was discussed (November, 1876), Dr. Greenfield and Dr.

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Goodhart related unsuccessful cases, and Sir William Jenner referred to three of "splenic leucocythæmia," in which the remedy seems to have had a really fair trial without any good result. The question was even raised, whether it might not be responsible for some fatty degeneration found post-mortem; but without laying stress upon that point the general conclusion of competent authorities, both at that time and since, has been adverse to the value of phosphorus in such cases.

It would seem, perhaps, to offer a better prospect in cases of *lymphadenoma* than of *leukæmia*, and especially in early cases, and more evidence must be collected before we can rightly estimate the true power of the drug. I have already referred to the increase of red blood-corpuscles, reported by Dr. Gowers, under the use of phosphorus; this was in a case of "lymphoma," and the increase in one month was from 52 to 66 per cent., and in another month to 74 per cent.; $\frac{1}{30}$ gr. was taken three times and then six times daily—no other drug was given, nor were the circumstances of the patient altered. The pathology of these maladies is, however, still very obscure, and they are not well defined one from the other. Greater clearness in their diagnosis and prognosis must be expected to precede therapeutic advance; but we may say this, that much more benefit has been already recorded from *arsenic*, both in pernicious anæmia and in lymphadenoma, than from phosphorus. The two remedies are, doubtless, allied, but the former claims much more reliance than the latter.

Bronchocele.—In nine cases of bronchocele (fibrous) I have made trial of phosphorus in varied doses, but without good result. Dr. Leech (Manchester) has sometimes seen the growth subside under the use of this drug, after iodine had failed (B. M. J., i., 1874), and it *may* occasionally prove a resource. Dr. Moxon has pointed out that glandular tumours vary in size, not only under various remedies, but sometimes without apparent cause.

PREPARATIONS AND DOSE.—*Phosphorus:* dose, $\frac{1}{100}$ to $\frac{1}{60}$ gr., less or more. *Oleum phosphoratum* (made with oil of almonds previously heated to 300° F. to destroy organic impurities); 5 min. contain $\frac{1}{32}$ gr.: dose, 3 to 10 min. *Pilula*

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phosphori (made with tolu and yellow wax); 5 gr. of the pill contain $\frac{1}{16}$ gr.

An exception has been taken to these officinal preparations—to the *oil* as disagreeing with the stomach, to the *pill* as being too concentrated, or not soluble enough; and many other formulæ for the medicine have been published (B. M. J., i., 1879, etc). It is commonly agreed that the free unoxidized element will produce effects which none of its chemical compounds can do, and it is desirable, therefore, to give it in its pure unaltered state. It cannot be finely divided without risk of oxidation, and the vehicles of fluid preparations, especially oils, are apt to disagree with the stomach.

Devergie, Solon, and others state that a solution in any *vegetable oil*, exposed to light and air, is apt to decompose, with partial conversion of the element into hypophosphorous acid, which has toxic properties, and hence some untoward accidents that have occurred with the phosphorated oil. A solution in *cod-liver oil* is not liable to this, but Dr. Broadbent finds it soon becomes oxidized, and loses its effect.

An *alcoholic tincture* may be prepared by adding phosphorus in excess to boiling alcohol quite free from water; this will take up 1 gr. in 6 dr. 20 min. (Thompson), and, if carefully kept from light and air, will remain unchanged for some weeks. As the result of many observations, Dr. A. Thompson recommends 3 dr. 10 min. of this tincture (= $\frac{1}{2}$ gr. phosphorus) to be added to 1 oz. 40 min. of anhydrous glycerine, with 5 min. of spt. peppermint, and he finds this more stable and less disagreeable than any other form.

I myself prefer an *ethereal tincture*, in which 1 gr. phosphorus is first dissolved in 1 dr. of pure ether; and this solution, after standing some days, is mixed with pure alcohol, so that a proportion of 1 gr. in 500 min. is preserved. From $2\frac{1}{2}$ to 5 or 10 min. of this ($\frac{1}{250}$ to $\frac{1}{100}$ or $\frac{1}{50}$ gr.) are readily taken, mixed with water, and the preparation is stable enough for all practical purposes. It should not be kept longer than three to five weeks.

Chloroform, which dissolves 1 per cent. rather quickly, has been used by M. Beaumetz as a vehicle, in capsules or in wine, but it is nauseous, and not well borne. *Bisulphide of carbon* is really the best solvent yet known for phosphorus, but its

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depressant and sometimes toxic effects contra-indicate its use. *Water* will take up, after agitation, a minute but uncertain amount of phosphorus, and it is not practically available as a medium for it. *Capsules* or "perles," containing $\frac{1}{100}$ to $\frac{1}{30}$ gr. in the form of phosphorated oil, are carefully prepared by Morson and other eminent pharmacists, and have been preferred by many physicians. They should be given after meals, but, even so, are not free from risk of causing gastric irritation. *Pills* may be made either with the drug reduced and powdered, or with a solution. Mr. Batten recommends pills with white wax, Mr. Gerrard with resin, Dr. Radcliffe uses suet. I do not like the pilular form, but if it be adopted, oleum theobromæ is the best medium, though not easy to manipulate (Martindale).

The *phosphide of zinc* is a good form for administering in pill. Lemonade should be given at the same time. Dose: $\frac{1}{100}$ gr. to $\frac{1}{2}$ gr. The latter dose may nauseate.

IODUM—IODINE, I, = 127.

Iodine occurs in the form of iodide, with magnesium and sodium, in sea-water, and in many mineral waters, such as those of Kreuznach, Cauterets, etc.; also in sponges and seaweeds, in water-cress, beans, potatoes, etc. Molluscs, and the liver of the cod and other fish, contain iodine, and in the human organism minute quantities are commonly found.

PREPARATION.—Iodine is prepared from kelp, the residue of burnt seaweed, soluble iodides being extracted by water, treated with sulphuric acid, and distilled with manganese oxide. Free iodine volatilizes, and is condensed in receivers—

$$2HI \text{ (hydriodic acid)} + MnO_2 + H_2SO_4 = MnSO_4 + 2H_2O + I_2.$$

CHARACTERS AND TESTS.—Iodine forms heavy, dark, glistening scales, which stain yellow or brown, and have a peculiar irritating odour. It is volatile, rising in violet-purple vapour at 400°. The sp. gr. of this vapour is 8·7, that of the crystals 4·9. It is soluble in alcohol, ether, and chloroform, and in water containing salt or iodide of potassium, but very

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slightly soluble in pure water (1 part in 7,000). The best test for free iodine is starch solution, which forms with it a dark blue iodide. In testing an alkaline iodide, nitric acid or solution of chlorine must be added before the starch, which should be cold, for the iodide loses its colour on heating. The addition of caustic alkali also decolorizes the solution, iodide and iodate of the alkali being formed—$6I + 6KHO = 5KI + KIO_3 + 3H_2O$. Iodine is closely related, chemically, to bromine and chlorine (Halogens). It has a stronger affinity for oxygen than these latter; but, for all other elements besides oxygen, a weaker affinity.

COMPOUNDS OF IODINE.

POTASSII IODIDUM—IODIDE OF POTASSIUM, KI, = 166.

PREPARATION.—(1) By adding iodine to liquor potassæ in slight excess, as indicated by a pale-brown colour of the solution. (2) The resulting mixture of iodide and iodate of potash is then heated with finely-powdered charcoal, which deoxidizes the latter salt, so that iodide only remains: it is dissolved out and crystallized.

(1) $6KHO + 6I = 5KI + KIO_3 + 3H_2O$.

(2) $KIO_3 + C_3 = KI + 3CO$.

CHARACTERS AND TESTS.—Occurs in white crystals, usually cubical and opaque, but sometimes octahedral and transparent. When pure, these are odourless, but they commonly have some scent of free iodine, and if this is present they are tinged more or less yellow. The taste is saline. It is very soluble in water and in six parts of rectified spirit. Nitrate of silver precipitates a pale yellow iodide of silver, insoluble in ammonia. If this liquid be then acidified with nitric acid, no precipitate should occur; if it does occur, chlorides are present. The most important adulteration—not, however, a very frequent one—is the iodate of potash, and this is detected by its insolubility in rectified spirit, and also by the blue colour developed on adding prepared starch and a little acid, *e.g.*, tartaric.

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SODII IODIDUM—AMMONII IODIDUM (*not officinal*).

The iodides of sodium and of ammonium are prepared in a similar manner to the last described, and have similar characters, and may be tested in the same way.

IODOFORMUM—IODOFORM, CHI_3, = 394 (*not officinal*),

Is a teriodide of formyl, and may be prepared by adding chlorinated lime to an alcoholic solution of iodine, heated to 104° F., till the liquid ceases to assume a red colour. Confused crystalline masses of iodate of lime and iodoform precipitate on cooling; the latter is dissolved out by boiling alcohol, and deposited in small, pearly, yellow crystals of sweetish taste and penetrating characteristic odour. It is insoluble in water, but soluble in boiling spirits (10 parts), ether (20 parts); also in chloroform, bisulphide of carbon, and oils: partially volatilized by heat: contains nine-tenths of its weight of iodine (Bouchardat).

ABSORPTION AND ELIMINATION—Iodine may be absorbed to some extent by the unbroken skin, if the local inflammation excited be not too severe. A dilute solution is therefore better absorbed than a strong irritant tincture. M. Sée maintained that the unbroken skin would not absorb iodine at all, and that any systemic effects following its application were due to absorption of the vapour by the lungs (Med. Times, i., 1874), but I believe the facts are as above stated. If a limb be painted with tincture of iodine, and covered with oil-silk, drops of colourless liquid may be found upon it after a few hours; this liquid contains the drug altered in some way by the perspiration (Gubler), and a similar alteration possibly occurs before its absorption. The drug may certainly be absorbed by the skin in a bath containing iodine and iodide of potassium; nor is there any question as to its free absorption from serous and mucous membranes. Iodide of potassium and other alkaline iodides are not absorbed as such, even when applied to the skin continuously in lotion or ointment, but after being decomposed by the acids of the perspiration, or of lard, etc., they evolve free iodine, which may be absorbed, as proved by its appearance

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in the urine (Rabuteau). Iodide of ammonium is the alkaline salt most readily decomposed, but iodoform parts with its iodine still more readily (Lancet, i., 1863). Baehrach applied compresses with iodate of potash solution, 2½ per cent., to the limbs, and in healthy subjects found iodine in the urine after fifteen minutes—in fever patients only after an hour or more (Centralblatt f. Med., ii., 1879). By *mucous* surfaces these compounds are easily absorbed; thus, when a suppository containing 20 gr. of iodide of potassium was placed in the vagina, 18 gr. were absorbed in twelve hours; glycerine diminished the rate of absorption, whilst a little free iodine increased it (B. M. J., i., 1878, p. 897). *Serous* membranes absorb iodides still more rapidly.

Taken into the stomach in small or moderate doses, iodine coagulates and combines with albuminous material, and is probably taken up in part as an albuminate, though a larger proportion combines with the soda of the gastric juice, and becomes iodide of sodium before being absorbed. Rabuteau thinks this combination with sodium occurs, to some extent, in the blood.

Alkaline iodides are either absorbed unchanged, or as iodide of sodium.

Högyes has recently published observations on the absorption of iodoform. He states, that if introduced in an undissolved condition, the first step is its solution in whatever fatty matter may be at hand, *e.g.*, the chyme in the intestine, and oily constituents of organic liquids in subcutaneous tissue and serous cavities. The oily solution of iodoform next gives up its iodine to any albuminous principle present. The iodide of albumen thus produced is speedily taken up into the blood, while a few minute coagula and oil-globules are left behind. The iodine is gradually eliminated from the system in combination with potassium or sodium (Arch. f. Exp. Pathol. u. Pharmak., Bd. x. Hft. 3, 4).

Metallic iodides, such as those of iron, lead, or mercury, are decomposed, and also form iodide of sodium, which appears in the urine, whilst the metal passes by the bowel, or is deposited in the tissues. Absorption of iodides seems to be markedly promoted by ozonic ether (Day, Med. Times, i., 1871), by

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ammonia, and some other stimulants. Both iodine and the alkaline iodides are readily and rapidly eliminated by the different secretions, and may be detected in the saliva, the buccal and bronchial mucus, the tears, the milk, the perspiration, the urine, etc. R. W. Taylor has reported evidence of elimination of iodine by the skin in the case of a man with pityriasis, who took large doses of the potassium salt whilst wearing a starched shirt; he had profuse perspirations, and a dark coloration appeared on his back. After continued use of *iodoform* internally, iodine is clearly eliminated by the skin, as proved by the characteristic and unpleasant odour of the perspiration (Binz).

It would seem that almost all the iodine taken passes by the urine, for Scharlau recovered from that excretion 345 centigrammes out of 350 taken (Stillé). According to Melsens, very little can be traced in the fæces; he suggests that the iodine that is excreted into the intestine is taken up again by the lining membrane before it reaches the rectum. Rabuteau found a small quantity in the fæces, so long as it was present in the other secretions; if diarrhœa occurred the quantity was notably increased.

The *rapidity* of elimination varies with the quantity taken, a large dose giving evidence of its passage very quickly. Ranke found traces in the urine three and a half minutes after administration, and even sooner in the saliva. Nothnagel also found it early—in ten minutes in the latter secretion. Richardson found it in the urine within one minute of injecting tincture of iodine into an enlarged bursa, and three minutes after breathing iodide of ethyl, iodine could be detected in the urine. It is an important practical point that elimination of this drug is complete sooner than that of many others. Dr. Balfour noted that even if large doses of iodide of potassium had been taken for many weeks their elimination was complete within three or four days after ceasing to take them (Edin. Med. Journ., 1868). Dr. Duckworth, after a dose of 4 gr., found iodine in the saliva in five minutes, in the urine in twenty-five minutes; after twelve hours' interval it was still to be detected in both secretions, but after thirty-six hours in neither (Barth. Hosp. Rep., vol. iii.). Rabuteau, after 15 gr.,

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found traces in the urine for three days; after 150 gr. for ten days; not afterwards. The greater part was eliminated during the first day, little passed on the second, and scarcely a trace on the third; in the dog, elimination was somewhat slower. Claude Bernard, giving iodide of potassium, ceased to find it in the urine twenty-four hours afterwards; that he detected it in the saliva for three weeks must be considered exceptional. Speck has stated that in Bright's disease the kidneys do not eliminate iodine, and Dr. Duckworth could not detect it in one case after giving 10 min. of the compound tincture, but 3 gr. of the iodide of potassium gave evidence of its presence, only much later than usual, namely, one, two, or three hours after administration.[1] Baehrach, giving moderate doses of iodate of potash by the mouth to healthy subjects and to fever patients, traced the drug in the urine of both within fifteen minutes, but on injecting it under the skin, elimination in the former occurred in five minutes, but in the latter forty minutes later (loc. cit.).

As will be noticed again under therapeutical action, iodides have a remarkable power of eliminating with themselves various metals and possibly organic poisons previously circulating in the blood or deposited in the tissues.

PHYSIOLOGICAL ACTION.—*External.*—Locally applied, iodine in tincture, or strong aqueous solution, acts as an irritant or caustic. It stains yellowish-brown, permeates and destroys the epidermis, and if it reaches the true skin, causes severe heat and prickling, sometimes serous effusion and vesication, followed by desquamation or superficial scarring.

Volkmann and Schede found that a few hours after the application of iodine the white blood-corpuscles had escaped from the neighbouring vessels to such an extent as to give, under the microscope, an appearance of suppuration; disintegration and fatty degeneration of tissue-elements also occurred, and prolonged applications to the limbs of rabbits caused periostitis. Iodine has marked antiseptic and antizymotic power, and is fatal to the lower forms of life, both animal and vegetable.

[1] Iodine may be detected in any secretions by white starched paper, which should be moistened with the liquid and then touched with nitric acid containing some nitrous acid: blue iodide of starch will be developed.

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Its vapour, when inhaled, undiluted and in sufficient quantity, causes heat, irritation, and cough, and sometimes has occasioned bronchitis and hæmoptysis.

Frictions with iodide of potassium sometimes produce local irritation and an acneiform eruption.

It has been stated that iodoform does not cause local irritation, but I have known it do so when applied to abraded surfaces, especially inflamed ulcers; in ordinary cases it has some anæsthetic effect.

PHYSIOLOGICAL ACTION.—*Internal.*—**Mucous Membranes.**—The earliest and most marked evidence of the constitutional action of iodine, whether taken by the mouth or injected hypodermically, is furnished by irritation and catarrh of the mucous membranes. If iodine itself be used, as in the form of tincture, there is more liability to *local* irritation of the mouth and stomach than with the alkaline iodides, but the *distal* mucous irritation is the same with all forms of the drug. It is shown mostly in the throat and bronchi, the nose and eyes—parts that are all exposed to contact with carbonic acid gas, which it is supposed decomposes the iodide salt as it is eliminated, so that free iodine exerts its local irritant effect (Rabuteau). Others trace a similar decomposition to contact with ozone in the blood or in the air (Buchheim and Kämmerer, Virchow's Archiv). The irritation shows itself by pain and sense of pressure over the frontal sinuses, œdema, prickling, and heat about the nose and eyes, with sense of stuffiness and serous discharge like that of ordinary coryza. The dose that will produce these symptoms varies much with different persons, some being acutely affected by 1 or 2 gr., others not by 10 or even 20 gr. continued daily for a long time.

Circulatory System.—Iodine and iodides, especially the former, stimulate this system, rendering the pulse fuller and more frequent, dilating the capillaries, and increasing heat in the extremities.

After toxic doses, first palpitation and flushings, afterwards faintness, pallor, and collapse occur, and Benedict concluded, from observations on batrachia, that both cardiac action and respiration were paralysed (Schmidt's Jahrb., Bd. cxv). Högyes

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reports a similar conclusion as to the action of iodoform on dogs, cats, and rabbits (Med. Record, May, 1879).

The blood itself does not seem to be affected unless it be rendered more fluid, and disposed to exude, for a form of purpura —"iodic purpura"—has sometimes occurred under the use of iodide of potassium.

Dr. T. C. Fox records an illustration in an adult with syphilide, and convalescent from rheumatic fever. After the second dose of 5 gr., a copious eruption of purpura came out on the arms and legs; this gradually faded and again recurred whilst the medicine was continued. The eruption came again under each of the alkaline iodides, especially the ammonium salt; iodism occurred at the same time, but the syphilide got well: there was no evidence of renal or other organic disease (B. M. J., i., 1879). Dr. Stephen Mackenzie attributed fatal purpura in an infant to one dose of 2½ gr. of the same medicine, but, in his case, the sequence is not so clear as in some others alluded to by him (B. M. J., i., 1878). Dr. G. Thin, after microscopic examination of eruptions caused by iodide, asserts that the neighbouring capillaries are blocked, and their walls altered, but the patient from whom the specimens were taken was syphilitic (Med.-Chir. Trans., 1879).

Whatever the pathological processes may be, I am satisfied that tincture of iodine is liable to cause hæmorrhage from various organs, especially in phthisical subjects, and in those with uterine congestion. Kness has observed hæmorrhage from the lungs and uterus in poisoning by iodide of potassium (B. M. J., i., 1879), and extravasations of blood have been found post-mortem in animals poisoned by iodoform (Med. Record, May, 1879, 182). We are not yet able to reconcile this hæmorrhagic tendency with the clinical results obtained in the treatment of aneurism by iodide of potassium.

Nervous System.—Much disturbance of the nervous system sometimes follows the full action of iodine. It is marked at first by excitement with restlessness, tremor, anxiety, and insomnia, but this state is liable to be succeeded by feebleness and depression. Toxic doses have caused violent headache, and sometimes convulsion. Rilliet described neuralgia, tinnitus, disturbed intellect, and convulsion, as prominent symptoms in

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some cases of iodism. Altered vision and paralysis were noted by Brodie. "Occasional hyperæsthesia and temporary palsy of lower extremities" occurred in a man who was taking very large doses (90 gr. thrice daily) of iodide of potassium (S. A. Lane, Lancet, ii., 1873). Such symptoms, however, must be considered rare. H. Wood states that he has only seen the nervous system affected once, in his experience, even "with enormous doses," and then the patient, who had been taking 270 gr. daily, became "intensely sleepy and stupid," as if under the influence of *bromide*.

More complete observations have been made upon the action of *iodoform* on the nervous system. Mâitre compared the effects to those of alcohol. After moderate doses—½ to 1 gramme—a dog either lay at rest, or if made to rise, staggered and fell; next day it seemed well. After 3 or 4 grammes, intense excitement set in, with quickened circulation, convulsive contraction of limbs, and opisthotonos, like that of strychnine. These are symptoms as of iodine in the circulation, and the odour of this substance was strongly marked in the breath. It would seem that when not dissolved in the blood, iodoform acts as an irritant on the nervous system, but when completely soluble it induces muscular relaxation with insensibility (acting like a narcotic). Mâitre was one of the first to record its power of relieving nerve-pain (Bouchardat, Ann., 1857). Righini, considering its chemical relations with chloroform, argued that it should possess anæsthetic power, and proved that it did so to some extent; but its local effect, when directly applied, is much more marked than its general effect when taken or inhaled. Twenty grains placed in the rectum are said to destroy sensibility in the sphincter, so that defæcation is not felt (Morétin).

Franchino corroborated the fact of local anæsthetic action, and produced some amount of similar effect on the general system in dogs, birds, and rabbits, by making them breathe 2 grammes of iodoform vaporized by means of bellows in a closed chamber—a stage of excitement with muscular contraction was followed by sedation and anæsthesia for five or ten minutes; then gradual recovery. Binz, however, could not obtain so marked a result as this, which he attributed in part to the carbonic acid confined in the chamber (Archiv f. Exper. Pathol.

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Klebs, vol. viii., 1877). McKendrick, comparing the drug to chloral, found that 10 gr. dissolved in about 1 dr. of alcohol, and injected under the skin of a rabbit, produced profound sleep for four hours, and 12 gr. destroyed life; but, again Binz failed to verify this result, and attributed the sleep mainly to the alcohol. In his own experiments, 2 grammes in oily solution, administered subcutaneously to dogs and cats, produced but moderate sleep in the course of an hour, and 3 grammes impaired the functions of the brain and spinal cord without being necessarily fatal. He concludes that moderate doses exert some narcotic effect, especially on dogs and cats, but not so much as former observers thought, and that toxic doses kill by general paresis with lowering of temperature (Edin. Med. Journ., 1874).

Högyes, from recent observations made in order to reconcile the discrepancies in the above statements, states that large doses cause marked drowsiness in the dog and cat, not in the rabbit; also that during the somnolence reflex irritability is not much interfered with. Toxic doses cause death by gradual paresis of circulation and respiration (Med. Record, May, 1879).

Binz experimented also with the *iodate of sodium*, and found that in rather large doses this salt caused narcosis in animals. It proved especially poisonous to the respiratory and cardiac centres, and he suggests that both this salt and iodoform are decomposed and liberate iodine in the brain and cord.

Digestive System.—Iodine has a pungent taste, and in small doses causes heat and stimulation of stomach, with some increase of appetite. A dose of more than 1 gr. usually causes sickness, and 5 gr. give rise to salivation, pain in the abdomen, and diarrhœa; large doses may cause glossitis, local inflammation, and ulceration. Vomiting, burning pain, spasm, choking sensation, and impairment of the special senses were symptoms noted by Mr. Bainbridge after the taking of 1 oz. tinct. iodine B.P.; oil was given, and recovery occurred gradually (Lancet, ii., 1875).

It is remarkable that iodoform, though containing so large a percentage of iodine, does not usually irritate the gastric mucous membrane, unless in toxic doses. The alkaline iodides readily disorder the stomach in many persons, and though at first they

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may increase appetite, they afterwards impair it. Small quantities are apt to constipate, but if continued they produce diarrhœa with liquid, slimy stools. At times, gastric irritation and catarrh are the only marked symptoms of iodism (Rilliet). Leroy (Brussels) has adduced evidence to show that when gastric pain is caused by iodide of potassium, it is really due to adulteration with iodate (Med.-Chir. Rev., ii., 1857). Mialhe endorses this, and Melsens considers such adulteration dangerous; five dogs were poisoned by it (Mémoire, Brussels, 1865).

Rabuteau points out that either of the salts separately is unacted upon by weak hydrochloric acid, whilst their mixture is quickly decomposed by it with liberation of free iodine; also, if fresh gastric juice be mixed with starch in test tubes containing the one iodide, and the other iodate, no blue reaction occurs till the contents of the two tubes are mixed, implying that free iodine is the irritant agent in the impure salt, and that a pure alkaline iodide is non-irritant. Practically, however, I am satisfied that as pure an iodide as is obtainable will produce gastric irritation in some subjects. In the case of all iodine compounds, such irritation may be avoided or lessened by giving them freely diluted, and shortly after food.

Glandular System.—It is commonly held that iodine stimulates the absorbent glands to increased action. This may be an indirect effect consequent upon its breaking down and rendering more susceptible of absorption certain kinds of tissue. It may be connected also with its quickening capillary circulation in the secretory glands.

The salivary glands and the pancreas, and possibly the lachrymal glands and those of mucous membrane and the testes, have their secretion increased by it. Rutherford concluded that the bile was not affected in quantity (B. M. J., 1879).

The secretion of milk is usually lessened under the influence of iodides, and may be almost wholly prevented by small doses commenced soon after delivery. If already established it may be suppressed by the same treatment if the infant be not placed to the breast (Morris, Lancet, ii., 1864). There are, however, some observations to the contrary, *e.g.*, those of Lazansky

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(Med. Record, 1878), who states that iodine does not affect the secretion, and certainly it may be given to syphilitic nursing mothers without stopping the flow of milk when this has been established for several months.

Whether iodine can cause atrophy of true glandular structure is an important question which is not yet decided in the affirmative, though Rilliet accepts its truth in the case of the testes and mammæ. Moisisovitz states that iodine has this effect, but not the iodides; he refers to 800 patients (Canstatt, 1866).

Certainly large quantities have been given without any such occurrence. Rabuteau gave to a woman, in the course of six years, 3 *kilogrammes* of iodide of potassium, yet the breasts were not at all affected by it, and Velpeau never observed wasting in 15,000 cases treated by him (Med.-Chir. Rev., ii., 1860). On the other hand, one case of wasting of the testes is recorded, but is not convincing (Philad. Med. Times, iv., 661). An enlarged and hard gland will grow less under these remedies from absorption of hyperplastic material, and even a healthy gland may grow smaller from absorption of fat or epithelial products, but so far as I have seen, the breasts, etc., recover their natural appearance on omission of the remedy, which they would not do if the gland-structure were actually destroyed.

Cutaneous System.—Various forms of skin-eruption may follow the internal use of iodine or the iodides, the most usual being allied to acne in appearance, and (according to T. Fox) in pathology also, that is to say, connected with irritation of the sebaceous glands. Dr. Thin denies this, and connects iodic rash with alteration of the capillaries, but apparently rests his opinion upon a single (syphilitic) case (B. M. J., ii., 1878).

Dr. Duckworth did not find the sweat- or hair-glands affected, and speaks of the rash as a "vesiculating dermatitis" (B. M. J., i., 1879). The pathology is probably not alike in all cases.

The ordinary rash is at first papular and then becomes pustular, and affects especially the face, head, and back; sometimes an erysipelatous blush is produced, sometimes bullæ, ecthyma, or anomalous pustules (Hutchinson), and not uncommonly petechiæ, purpura, or hæmorrhagic effusion may be met with, as already mentioned. Much œdema of the eyelids sometimes

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occurs. The irritant effect upon the skin may be much controlled by arsenic.

Genito-urinary System.—The genital system is stimulated by iodine, sexual desire being increased under its use (Jörg); an increased flow of blood to the uterus is sometimes determined by it. If the iodide of potassium has a similar effect, it is much less in degree.

The effect of either preparation upon the urine is variable. Begbie speaks of iodide of potassium as one of the best diuretics (Lancet, ii., 1875), whilst Handfield Jones, out of six cases observed, found the secretion increased in three, but diminished in two (Beale's Archives, No. 3). Rabuteau observed no diuresis from 15-gr. doses. Wöhler, giving iodine to a dog, noted increase of urination, but only in proportion to increased quantity of water drunk (Zeitschrift, 1824). Bassefreund, from observations on himself, concluded that the urine in healthy persons was not augmented under iodides; at first, it was rather lessened in quantity (Canstatt, Jahrb., 1859). Very large doses may irritate and congest the kidney, and induce albuminuria, in which case the amount secreted would naturally be lessened (Grubler). Mr. Hutchinson "suspects that iodides may cause Bright's disease" (Lancet, ii., 1876). Dr. Simon found that albuminuria occurred in the majority of children that had tincture of iodine externally applied, whether to the scalp, the chest, or the knee (B. M. J., ii., 1876), although from the analyses of Dr. Ord in a case of iodine-poisoning the urinary precipitate in such cases would seem to be mucin rather than albumen. As remarked by Mr. Spencer Wells, the alkaline iodides have some power in dissolving uric acid, but this is due probably to the alkali rather than the iodine. H. Jones obtained very discordant results from iodide of potassium; in some cases the uric acid, urea, and other constituents being diminished, in others increased.

In Dr. Ord's case, urea and uric acid were largely *increased*. In diabetics taking iodide, the same thing occurred (Bouchardat).

On the other hand, Rabuteau, taking daily, for five days, 15 gr. of iodide of potassium, reported marked *diminution* in his urea-excretion to the extent, some days, of 40 per cent. during the period of experiment, and for nearly a fortnight afterwards.

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Influence on Nutrition.—From the above discrepant results, it becomes difficult to theorize concerning the action of iodine on nutrition, and further reliable analyses of the excretions under its use are highly desirable. The French physiologists concluded that its influence resembled that of arsenic, *i.e.*, was more of alterative, modifying character, than absorbent and eliminant. My own observations lead me to place more stress upon the latter. Although the medicinal use of iodides in certain disorders may bring about an improved state of the nutrition (Wallace found, for instance, that his syphilitic patients gained flesh under its use), yet, when given continuously to persons of average health, these medicines usually impair nutrition, and induce more or less emaciation. This affects the periglandular and fatty tissues, rather than the true glandular structures, and it may be connected either with disturbance of digestion, or with certain important physical effects recently traced to iodide of potassium. One of these is the increased rate of circulation produced in capillary tubes when that salt is added to the circulating fluid (Poiseuille), and the other is its dissolving the central substance of starch-granules with great expansion of peripheral layers, so that the grains become twenty-five to thirty times larger than normal (Payem). We may suppose that, introduced into the human economy, the drug both quickens capillary circulation and dissolves glycogenic material.

PATHOLOGICAL CHANGES.—After death from *iodoform* fatty degeneration has been found in the liver, kidneys, heart, and voluntary muscles. Binz attributes this to the setting free of iodine in the body.

IDIOSYNCRASY—TOLERATION.—There is much difference in the susceptibility of persons to the action of iodine, and we can explain this in no better way than as "idiosyncrasy." Speaking generally, it may be said that pale, thin, languid patients often bear it better than the stout and plethoric who have a tendency to active head-congestion or stasis of circulation. Such subjects, if rheumatic, are often intolerant of even small doses; so are the sufferers from goître or exophthalmos, or nervous palpitation accompanied with irregular flushing and impaired vaso-motor power.

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Climate and soil seem to have some influence, for Coindet's patients, in Geneva, were much more susceptible than those of Ricord, in Paris (Med.-Chir. Rev., ii., 1860). Dr. Lisson concluded that people with fair skin were more susceptible of the action of this, and all other drugs affecting the skin, than dark subjects, and this may prove some guide. He himself was able, by commencing with small doses, to induce a state of toleration, so that he could take 100 gr. of iodide of potassium without marked effect (Lancet, i., 1860). On the other hand, 3-gr. doses have caused severe inflammatory attacks (Lancet, ii., 1873, p. 119), and even a less quantity may excite distressing coryza. Bad effects may, however, be often avoided by following Lisson's plan, and inducing tolerance, *e.g.*, I gave a patient with syphilis iodide of potassium in 3-gr. doses thrice daily, but he always suffered from coryza and headache after two or three days; then it was reduced to 1 gr., and the same results followed; then he took ½ gr. thrice daily and had no ill-effects, and the dose was gradually increased, and in a few weeks he was able to take 15 gr. three times daily without any bad symptoms. In one (exceptional) case, iodism setting in after the fourth dose of 3 gr. of iodide of potassium affected the larynx so intensely as to require tracheotomy (Lancet, ii., 1875), and, as already mentioned, Dr. S. Mackenzie traced fatal purpura in an infant to 2½ gr.; but the question may be raised whether the salt was quite pure in such cases. It has also been mentioned that evil results have been attributed to an admixture with iodate of potash, and in such exceptional cases an analysis should be made with reference to this point. *Acute* iodism is generally proportioned to the largeness of the dose; but the *chronic* condition is more readily induced by continued small doses. The iodides of sodium or ammonium are often (not always) better borne than the potassium salt.

SYNERGISTS.—The stimulant action of iodine is increased by warmth, alcohol, ozonic ether, the essential oils, etc. Ammonia has been especially found to assist its effect and enable it to be borne, either by chemical combination with it, or by determining free circulation in the skin.

The absorbent effect is remarkably aided by the simultaneous use of mercury, and *vice versâ* (B. M. J., i., 1875).

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ANTAGONISTS AND INCOMPATIBLES.—Cold, quinine, digitalis, the alkaline bromides, and other sedatives to the circulation, moderate or antagonize in part the specific action of iodides; this fact, however, does not prevent their combination for therapeutic purposes. Starch and albuminous substances are the best chemical antidotes to iodine in cases of poisoning.

Carbolic acid and liquor ammoniæ enter into combination with the drug, and remove its brown colour, but are said not to lessen its active properties. I have not, however, obtained as good curative results in absorption of tumours from the ammoniated iodine as from the pure drug. Bismuth subnitrate, which is sometimes prescribed with the iodide of potassium, precipitates an insoluble red iodide of bismuth. The organic alkaloids, strychnia, atropia, etc., are precipitated by iodine—according to Dr. Fuller, 1½ gr. of strychnia by 1 dr. of tincture of iodine; hence he and other observers have thought them mutually antidotal, but the compounds formed are themselves poisonous (Med. Times, i., 1861; Lancet, i., 1868), and require removal from the stomach as much as the original poison (Lancet, i., 1876). The iodide of starch may be antidotal to sulphides and to caustic alkalies, as stated by Bellini.

THERAPEUTICAL ACTION.—*External.*—Iodine is used (both alone and combined with iodide of potassium or with camphor) in tincture, liniment, and ointment, as a mild stimulant, or strong counter-irritant, or a caustic, according to the strength of the application. It causes pain when applied freely, and in children, and delicate tuberculous subjects, should be used with special caution.

Strumous Glands.—"Iodine paint" is a common and often a useful application to enlarged and hardened glands in the neck, groin, etc.; but sometimes the constant application of iodine lotion (½ oz. of tincture to ½ pint of water) gives a better result, and is less painful. Mr. F. Jordan recommends painting iodine not *over* but *round* the enlarged glands, and this is sometimes more advantageous.

If suppuration has occurred, the tincture should be painted over the neighbouring thin skin; and if the open sore remain

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indolent, it should be dressed with iodoform ointment, or with a solution of about 2 dr. of tincture in ½ pint of water, and applied on lint covered with oiled silk. In certain chronic glandular enlargements, the direct injection of iodine tincture acts better and more quickly. Bonalimi (Med. Record, 1876) found it more serviceable when the growth was not scrofulous; but Mr. Bradley, writing more recently, recorded a very favourable experience—(1) in true hypertrophy of lymphatic glands; (2) in strumous hypertrophy, before softening has occurred; (3) in hard multiple lymphomata and encapsuled cervical tumour. He used from 5 to 10 min. of tincture, at intervals of four to five days (Lancet, ii., 1875). Marston was one of the first to use this method.

The application of iodoform ointment or iodoform collodion deserves trial before resorting to the injection. I have seen some cases as remarkable as the following, recorded by Dr. J. Moleschott. A scrofulous man had a growth of cervical glands the size of a large fist, which was but little affected by iodide and bromide treatment, internal and external, and continued for nearly three years. In November, 1870, collodion 15 parts and iodoform 1 part were ordered to be applied night and morning; in one month the tumour was reduced one-half; in April it had disappeared; six years after it had not recurred. Two children with similar cervical growths, unaffected by ointment of iodide of potassium, were cured in a few weeks by iodoform; and a woman, in whom the growth was of "cartilaginous hardness," and as large as a hen's egg, and of some years' existence, obtained benefit after three months' use of iodoform ointment (1 in 15), and cure within twelve months (Med. Record, Nov. 15, 1878).

Enlarged Tonsils.—These are often connected with the strumous diathesis, and iodine tincture is one of the best local applications, though it is an unpleasant one, and sometimes excites much irritation. After some absorption has occurred, I follow its use with the solution of perchloride of iron. In obstinate cases, a few drops of iodine tincture have been injected into the substance of the tonsil with good result.

The internal use of the drug, or of iodides and cod-liver oil, is desirable at the same time.

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Bronchocele.—In cases of fibrous and fibro-cystic bronchocele, where calcareous degeneration has not occurred, local applications of iodine should be combined with its internal use. If the part be tender or inflamed, soothing fomentations, or even moderate leeching, may be needed before using iodine; then either the liniment may be painted on once or twice daily for several days, according to the degree of irritation produced, or an iodized collar may be worn (made with iodine sprinkled on wool), or iodoform, or iodide of mercury ointment may be rubbed in as described (*v.* Mercury). I have sometimes been disappointed with the mere external use of iodine in bronchocele, but have had excellent results from its *injection* into fibrous and fibro-cystic cases (25) in which I have used it. In one large fibro-cyst, as to which there was difficulty of diagnosis, no fluid being suspected, 30 min. of the tincture were injected, and considerable diminution of the growth followed: a month afterwards 3 oz. of fluid were drawn off, and the cyst injected with 2 dr. of a solution containing 1 part of tincture to 3 of water. The man was highly scrofulous, and the growth of long duration; but after the inflammatory condition set up by the iodine had subsided, the bronchocele disappeared and gave no further trouble. The only case in which dangerous results occurred was one in which some iodine solution escaped into the cellular tissue, and sloughing of the part followed. Nineteen out of the 25 cases got well, 2 of them having been injected seven times. Lately, Dr. Lücke, of Berne, has reported equally good results in the fibrous form of enlargement. Of 16 cases treated by him, 11 were cured and 4 improved; and Dr. Morell Mackenzie, who at first considered this method inferior to others, records his later experience of it as very favourable. He obtained unexpected cures in fibrous and adenoid cases from the weekly or bi-weekly injection of 30 drops of tincture (Med. Times, i., 1872, and B. M. J., ii., 1873). Dr. Luton speaks well of similar injections of iodic acid—1 part to 5 of water,—he uses about ½ dr. at one time (Lancet, ii., 1873, p. 457). (*v.* Internal Use.)

Orchitis.—If hardness and swelling of the testicle remain after subsidence of the acute stage of this malady, iodine

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lotion or ointment, with strapping, will prove effective. Alvarez has reported exceptionally good results from iodoform ointment (1 to 2 gr. to 30 of simple ointment) in blenorrhagic orchitis. It is said to relieve pain in one to two hours, to shorten the duration of the malady and of subsequent induration, and "exert a resolvent action" without any constitutional disturbance like that of mercury (Med. Record, 1877).

Prostatitis.—In subacute and chronic enlargement affecting the prostate gland, I have seen much advantage from iodine, and still more from iodoform ointment, though Sir H. Thompson, in his treatise, does not speak favourably of the former, nor does he mention the latter.

In cases of chronic enlargement, Heine states that he has injected the tincture into the substance of the gland, with successful results (Med.-Chir. Rev., i., 1873).

Mammary Growths.—Congestions and localized hardness and obstruction of mammary ducts are amenable to iodine frictions, but the skin of the breast is very sensitive and easily irritated. I can recommend a weak solution of iodoform (1 in 15 to 30) for many of these mammary growths. In 1871 I ordered it for a lady with a large, suspicious-looking tumour, which was to have been removed the following week under the advice of an eminent surgeon. The growth quickly diminished under the iodoform, and the lady is now (1880) quite well. This is only one of many similar instances which have come under my own observation.

Pleuritis—Phthisis.—The external use of iodine will frequently relieve subacute pleuritic pain and the "flying" chest-pains which are common in phthisis. Iodoformed collodion (1 part in 15 to 20) is said to act especially well in such cases, and to exert the further effect of lowering the body-temperature (B. M. J., i., 1879). In chronic pleuritis with effusion, iodine liniment or ointment has some power to promote absorption; and in phthisis and chronic bronchitis, painting it over the front part of the chest serves to impregnate the air which is breathed, and modifies expectoration and the state of the bronchial membrane. Inhalation of iodine may also be practised, and a few grains may be left on a plate in the sick-room with advantage. Fœtid organic odours from the breath,

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etc., are lessened by it (Richardson, Social Science Rev., July, 1864). Iodine, 10 gr., dissolved in 1 oz. amyl hydride, makes a good inhalation (Med. Times, ii., 1871).

Diphtheria—Croup.—I have found an iodized spray or inhalation often useful in these maladies. Dr. W. Curran gives a good formula, containing 4 gr. each of iodine and iodide of potassium in ½ oz. alcohol and 4 oz. water. Of this one to four teaspoonfuls may be added to a pint of boiling vinegar or water, and the vapour inhaled every two hours for five to ten minutes.

Menzel has injected a few drops of tinct. iodi into the soft palate and tonsils in diphtheria, and apparently with success (Med. Times, ii., 1873).

Chronic Peritonitis.—In this malady, especially when occurring in strumous subjects, and accompanied with enlarged mesenteric glands, the external use of iodine in the form of ointment, liniment, or compress, should be conjoined with internal treatment.

Chronic Visceral Congestion.—In chronic congestion of the liver and spleen, the external application of iodine is often useful.

Uterine Congestion, etc.—In congestive enlargement of the uterus, with some induration of the cervix connected with sub-involution or chronic inflammation, benefit may be derived from iodine locally applied. Tepid injections containing 1 to 2 dr. of the tincture in a pint of water, and also iodized hip-baths are useful. Dr. Greenhalgh prepares an "iodized cotton" by saturating 8 oz. of cotton in the same quantity of glycerine, containing 1 oz. of pure iodine and 2 oz. iodide of potassium, and keeps a pledget of this pressed for some hours against the cervix, withdrawing it when necessary by a thread secured to it. Dr. Graily Hewitt applies the tincture directly to the inflamed part, and recommends this treatment especially for patients of sluggish habit and scrofulous diathesis. My own experience of this treatment in similar cases is favourable. Dr. James Bennett recommends direct injection of an iodized solution in chronic cervical metritis (Dub. Med. Journ., Oct., 1878). In cases of granular erosion and ulceration, the iodide of silver, prepared extempore as recommended by Dr. Wright, by adding a few drops of iodine tincture to some nitrate of silver solution, may be used with much advantage (Diseases of Women).

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In amenorrhœa dependent upon torpor of the uterine system, local applications of iodine are useful.

Menorrhagia.—In persistent cases Dr. Savage, and also Dr. Routh, have used intra-uterine injections of iodine (Lancet, 1851; Med. Times, i., 1860), but this treatment involves too much risk for ordinary use. In chronic uterine leucorrhœa Dr. G. Murray applies the remedy by means of a sound, which is safer than injection (Lancet, 1866).

Injection of Cysts—Hydrocele.—The injection of iodine in cases of hydrocele gives better results than any other remedy. Port wine and tincture of iron are both very inferior to it. The serous fluid should first be evacuated thoroughly, and then 1 to 4 dr. of iodine tincture injected (according to the size of the cyst). Sometimes inflammatory reaction occurs, and lasts two to six weeks, but the ultimate result is usually good. I have seen one case of fifteen years' duration, where the scrotum hung nearly to the knees, and was supported by a sling round the neck; after puncturing and evacuating, 6 oz. of iodine tincture were injected: the physiological effects were strongly developed, but complete cure followed.

I believe that Sir Ranald Martin introduced this method of treatment, but he diluted the tincture with two parts of water.

Mr. Furneaux Jordan has recently written to advocate the use of two or three threads soaked in the tincture and drawn through the hydrocele, to act like a seton. This succeeds in some cases (Lancet, i., 1876).

Spina Bifida.—I have not myself had much experience recently in the use of iodine in this deformity, and what I had in former years was not favourable; but the results of Dr. Brainard, Dr. Morton of Glasgow, and others, have placed the operation on a new basis. The latter surgeon, in 1876, reported fourteen cases, eleven of which were successful; and in the majority, not only was the sac obliterated, but improvement as to paralysis and general health occurred. The cases were not simply those in which connection with the spinal canal was naturally obliterated, and which might fairly be expected to recover, but included some of much more serious nature. The solution used ("Morton's solution") was—"iodine 10 gr., iodide of potassium 30 gr., glycerine 1 oz.," and of this ½ to

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1 dr. was injected after removal of more or less fluid according to the case (Lancet, ii., 1876).

Dr. G. W. Thompson records an instructive illustration, in which the tumour over the sacral region was twelve inches in circumference ten days after birth; it was attached by a peduncle and communicated with the spinal canal. After tapping and removing about 2 oz. of fluid, 25 min. of Morton's solution were injected and the aperture sealed. There was much shock, and brandy was given freely. Gradual improvement, however, took place, and six months afterwards only a mass of thickened skin remained (B. M. J., ii., 1878).

My colleague, Mr. Pearce Gould, has recorded an interesting case of recovery under similar treatment. The child, aged eighteen months, had a sessile tumour, as large as a cricket ball, situated over the last lumbar and sacral vertebræ, and communicating with the spinal canal. At the first operation 6 dr. of fluid were drawn off, and ½ dr. of Morton's solution injected; at the second operation 1 oz. was removed and 1 dr. injected; at a third, 2½ oz. removed and 2 dr. injected. There was neither shock nor convulsion; improvement set in on the ninth day after the last operation, and ultimately only a flat mass of dense tissue remained: there was no paralysis (Clin. Soc. Trans., vol. xi.).

Of two other cases treated by Mr. Gould, after Morton's method, one died of purulent spinal meningitis a few days after the second injection; the other left the hospital and was not seen again.

Hydrarthrosis.—In extensive chronic serous effusion in the knee-joint, injection of iodine has been successfully practised by Velpeau and others. One part of iodine, 2 of iodide of potassium, and 8 of water, are injected in about the same quantity as is withdrawn by aspiration; air should be carefully excluded from the wound. Mr. C. Macnamara has injected 1 oz. of the pure tincture with quite satisfactory result (Lectures on Diseases of Bones and Joints, 1881).

In less severe cases of effusion, in bursal effusions (housemaid's knee), and in rheumatic and gouty joints, the external application of iodoform, or iodine paint, promotes absorption, and should be tried before puncture. Dr. Fuller recommended a lotion containing ½ oz. of tinct. iod. co. in 6 oz. each of glycerine and water, and applied on lint covered with flannel; frictions

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and douches should be combined with this treatment (Lancet, i., 1863).

Pleuritic Effusion.—The external use of iodine, combined with pressure, aids in the absorption of such effusions, and some surgeons have, in chronic cases, injected a weak iodine solution (4 to 5 gr. to the pint) into the pleural cavity, and with ultimate success. It seems to be, however, an operation of unusual risk, and one which has been followed, more than once, by death from inflammatory reaction, embolism, or shock (*v.* Empyema).

In **Ascites** of chronic character, M. Boinet injected iodine, in the first instance by mistake, thinking the case ovarian, but after a very serious attack of peritonitis, the patient at length recovered (Iodothérapie, 1855). Leriche, Dieulafoy, and some few other surgeons have recorded similar cases, and remark that the ascitic fluid should not be all evacuated previous to injection, so that moderate dilution of the iodine may be insured. Dr. Ford, (U.S.) has recently reported two case of ascites cured by iodine injection, so that the operation is by no means obsolete. One of his cases "was connected with renal mischief," the other "followed on cessation of the menses." After tapping, he injected 2 oz. of tinct. iodi with an equal quantity of water (Practitioner, i., 1877).

The cases here alluded to are not very clearly described by their narrators, but we must recognize that those suited for this method of treatment can only be of certain kinds; for instance, such as are dependent on chronic peritonitis, or simple anomalies of secretion, or perhaps on hepatic disorder, but not cases of ascites connected with cardiac or advanced renal disease, or anæmia.

Empyema.—In chronic cases, provided a free opening is secured, an iodine injection (1 to 2 dr. of tr. in the pint) is sometimes serviceable, both to disinfect and to stimulate healthier secretion and contraction of the cavity, and many patients have, doubtless, recovered under its use. Dr. Dickinson speaks of it as better than any other treatment in his experience (B. M. J., 1876). On the other hand, I have myself known it excite much undue irritation, both local and systemic. In some cases, sudden, or nearly sudden, death has followed the injection of iodine solutions into the pleural cavity, but we cannot

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reasonably attribute the result to iodine, because in the very same cases iodine had been previously used without harm, and besides, sudden death has followed, in a similar manner, the injection of warm water, of carbolic acid lotion, etc. The effect may have been connected, rather with mechanical conditions, such as insufficient freedom of exit, too great pressure of fluid, etc., or else, with special cardiac conditions of feebleness, dilatation, etc., but certainly, I am strongly of opinion, that injections into the pleural cavity are never without some risk, and can seldom be practised safely; they should be discontinued in favour of free drainage with strict antiseptic precautions.

A little of the solid iodine, placed in perforated chip-boxes in or near the bed, forms a good disinfectant in cases of foul wounds, discharges, etc.

Pericardial Effusion.—I have treated several severe cases of this condition by iodine injections: for instance—(1) G. H., aged thirty-seven, had in youth two attacks of rheumatic fever with endocarditis of aortic valves: when otherwise robust, a third attack came on in August, 1876. In November, when I first saw him, there was extensive pericardial effusion, with visible bulging and fluctuation; cardiac dulness extended beyond the right of the lower sternum, and upwards as high as the second rib; the heart-sounds were feeble and indistinct, and the respiration impeded; there was a short dry cough, and extreme orthopnœa, so that life was in imminent danger. I drew off 3 oz. of fluid, and injected 10 min. of iodine tincture; relief was experienced, and I repeated the operation in forty-eight hours. After this the man gradually recovered, though eight months afterwards he died suddenly from his aortic disease. (2) In another man, aged twenty-three, also suffering from extensive pericardial effusion, with intense dyspnœa and other urgent symptoms, 2 to 3 oz. of fluid were drawn off by aspiration (with much relief), and 10 min. of iodine tincture injected. Thirty hours afterwards, 10 min. more were injected; no symptoms of iodism appeared, and the patient made a good recovery. In both cases, 4 to 6 gr. of iodide of potassium were taken in bark thrice daily, before and after the operation.

Abdominal Cysts.—The following case, which occurred in

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my practice some years ago, will illustrate some of the risks and the possibilities of treating large cysts by strong iodine injections. A gentleman, aged seventy, had an enlargement of the abdomen which was obscure in its nature, and variously diagnosed as dependent on liquid effusion or a solid growth from the under surface of the liver. Attacked one day with rigors and sudden, violent pain, he became jaundiced and collapsed, and when seen by me was semi-comatose and apparently dying. Some obscure fluctuation being detected in the enlargement, a trocar was inserted and 21 to 23 pints of thick grumous fluid, with some pus, were drawn off; this was examined by special microscopists without detection of any hydatids or hooklets. Three weeks afterwards, 16 pints of fluid were drawn off, and 16 oz. of pure tincture of iodine (B.P.) injected, allowed to remain for twenty minutes in the sac, and then some of it to escape.

Severe effects soon followed the injection—salivation, soreness of mouth and throat, sickness, eructations, headache, giddiness, tinnitus aurium, muscæ volitantes, etc., accompanied by palpitation and pyrexia: the pulse was 140, weak and irregular, the temperature 101·8° F. Epistaxis occurred twice during the first thirty-six hours; tightness across the chest, and pain at the epigastrium were complained of, and frequent thin watery stools were passed; the general condition was one of extreme nervousness, prostration, and unrest.

On the second and third days the temperature, which was highest in the afternoon, varied from 101° to 104° F., and the pulse from 110 to 140. Pains in the limbs and in the loins set in, and were felt also in the long bones, which presented all the evidence of periostitis; synovial effusion distended the left knee-joint; the urine, which was at first pale and profuse, became scanty and bloody, and both it and the saliva contained large quantities of iodine; the salivary glands were painful and swollen, and the palate and fauces sore and inflamed; there was constant short dry cough with more or less aphonia.

All these symptoms continued to increase until the end of the fourth day, when an eruption, somewhat like measles, appeared, with apparent relief to many of the urgent symptoms. By the fifth day, the periostitis had considerably subsided, and by the ninth, most of the other symptoms had disappeared.

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Iodine was, however, excreted by the urine for about sixteen days, and albumen for twenty-five days; during the whole time nourishment was taken well. After the severe attack convalescence progressed favourably, and the patient lived for two years afterwards, and died from the effects of cholesterin calculus.

Ovarian Cysts.—When the cyst is unilocular and no acute symptoms present nor active growth going on, then the injection of iodine may in some instances prove useful, although the radical operation of removing the diseased ovary has now such an average success that the less certain method of injection is seldom employed. M. Boinet records 45 cases, treated by tapping and injecting equal parts of iodine tincture and water, allowing this to remain for a few minutes whilst the abdomen was gently manipulated, then to escape; 31 out of these cases are said to have been successful, whilst 9 ended fatally. This is a much higher mortality than after ovariotomy.

Velpeau, Simpson, and Spencer Wells have also obtained, on the whole, favourable results with the same method (Med. Times, ii., 1860), but Dr. Tyler Smith succeeded in only 2 out of 10 cases in which he employed it, and of 6 patients treated by Schuh, only 1 was cured and 1 relieved. My own experience of injection in ovarian dropsy, though not large, is rather favourable. In one case, now nineteen years ago, I withdrew a pint of fluid from a large cyst, and injected 4 oz. of iodine tincture, and after repeating this three times, absorption ultimately took place, and the lady, now living, has had no further inconvenience. In another similar case in which I drew off a pint of fluid, and injected 2 to 3 oz. of iodine tincture, severe physiological effects followed, and continued for ten days; but the patient soon rallied, and three months afterwards 4 oz. more were injected, and absorption of the cystic fluid rapidly took place: this was in 1864, and at the present time there remains only a growth the size of an orange, which gives rise to no annoyance.

In both cases the cysts were judged to be unilocular, and were of some years' duration, but the operation, though favourable in result, required repetition, and produced for a time troublesome symptoms. It is clearly not one to be adopted without much consideration, and only for cases such as those described, where

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the patients would not submit to removal of the ovary. Sometimes a fatal issue has followed directly from iodine injection, as in the often-quoted case of Dr. E. Rose. He injected into an ovarian cyst 5 oz. of iodine tincture containing 1 dr. of iodide of potassium, and severe symptoms of iodism and collapse immediately set in, with vomiting and cyanosis; scanty dark urine, containing iodine, was excreted; three days afterwards, the cutaneous capillaries dilated, the face flushed, maculæ appeared on the skin, and hæmorrhage occurred from the lungs and uterus.

On the eighth day, most of the urgent symptoms had disappeared, but the urine still contained iodine and albumen; on the tenth day, death occurred suddenly from cardiac failure (Nothnagel).

Ranula.—It has been recommended to inject the sac of a ranula with iodine after emptying its contents; I have made numerous trials of this plan, but have abandoned it as unsatisfactory.

I used it three times in one case, but with no other result than to cause much irritation; cure was ultimately obtained by dilating the duct-aperture with laminaria.

Abscess Cavities.—The injection of iodine has been resorted to, and sometimes with success, for the purpose of disinfecting such cavities and controlling the secretion of pus.

Boinet gives the history of a chronic abscess occupying the whole right iliac fossa; it followed a bubo, and discharged profusely by a fistulous tract. After many months of unsuccessful treatment by injections, ointments, nitrate of mercury, potash, compression, etc., he injected a solution of iodine (2 dr. of tincture in 4 oz. of water) to the bottom of the cavity through a catheter; much pain followed, and afterwards severe febrile reaction, but in about a fortnight radical cure was obtained (Iodothérapie). Such successful results cannot be always depended upon, and, in fact, I have known injury from this mode of treatment in many such cases; for instance, in one case of psoas abscess an injection containing 1 dr. of tincture in 3 oz. of water was practised three times in a fortnight, but considerable irritation and increase of hectic was set up without subsequent improvement; after an interval of four months it was repeated (1 dr. in 4 oz.), but with the same result, and the patient

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died shortly afterwards; vertebral caries was found, but only slight in amount.

In another similar psoas abscess, where the malady was not recognized until an opening in the groin had nearly occurred, iodine was injected, and induced much hectic and aggravation of symptoms; no improvement could be traced to repeated injections, but the patient is still living.

In smaller abscesses I have found the injection of iodine beneficial; it offers less risk than in large psoas abscess, and is more likely to succeed. Mr. Stirton found it answer well in a chronic scrofulous abscess of the groin—he used 2 gr. to 1 oz. of water (Med. Times, ii., 1870).

Fistula.—In some cases, iodine injection is said to have answered well. Lachrymal fistula has been cured by it (Lancet, i., 1874), also congenital branchial fistula (Med. Record, 1879). In rectal fistula an ethereal solution has been of service (Lancet, ii., 1872), but should not be allowed to remain in the bowel as it may cause severe pain (Med. Times, i., 1860). A good colourless disinfectant and cleansing lotion for such cases is made with tinct. iodi ʒiss., glycerini ʒij., sol. calcis chlorin. ʒvi.; use ½ oz. to 6 or 8 oz. of water (Dr. Boggs). Mr. Stirton has related a case of rectal fistula in which the ordinary operation had failed several times, but succeeded when iodine injection was commenced immediately after it. In my own experience, I have never known iodine by itself cure anal fistula, and should always recommend an operation in preference to injections of any kind. Iodized injections are, however, often useful in stimulating old atonic sinuses in the neighbourhood of joints, etc.

Fissure of Anus—Hæmorrhoids.—An ointment or suppository containing iodoform—5 to 15 gr. in the ounce—relieves the pain in defæcation connected with these maladies.

Ulceration.—When the skin is broken and there is purulent discharge, as in severe burns or chilblains, or after wounds or injuries, iodoform ointment or lotions of iodine will disinfect the pus, relieve pain, and promote healing. I agree with M. Lailler (Hôpital St. Louis), who states that the former preparation acts as a local anæsthetic, and favours cicatrization in a remarkable degree, "it modifies ulcers of every variety," but should not be

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used whilst they are acutely inflamed; this stage being passed the surface should be carefully cleansed and dried, and then either the finely-powdered crystals or a solution in sulphuric ether (1 part to 8 or 10) should be pencilled over and covered with lint; the ether evaporates, leaving a thin film of iodoform (Med. Record, Feb., 1878). From observations in eczematous cases, Mr. Squire concludes that it is best used during the puriform stage, and ceases to be suitable when the discharge becomes purely serous—he prefers a glycerole (B. M. J., i., 1881). Dr. Richardson speaks highly of a solution of iodine—20 gr. in amyl hydride 1 oz.—for painting over suppurating wounds; this also leaves a thin protective film. Or the vapour of iodine may be applied by putting a few grains of the element between a fold of lint, which is placed over the wound and covered with cerate and oiled silk.

In ulceration about the mouth and tonsils, and in the severe form called "cancrum oris," touching with strong iodine solution is often curative.

Onychia.—The duration of this very painful and obstinate form of suppuration may be much shortened by iodoform ointment, of strength 1 dr. to 1 oz. (Med. Times, ii., 1872; Med. Record, 1878). I have used it frequently with excellent results.

Gingivitis—"Tartar."—The local application of tincture of iodine will usually cure inflammation, sponginess, or tenderness of the gums, and will soften deposits of "tartar," so that they may be readily removed with the brush.

Ulceration of Tongue—Gumma.—In obstinate syphilitic affections of this description, with ragged, thickened epithelium, deep fissures, and severe pain, Mr. Berkeley Hill has found iodoform very useful, applied locally to the part and given internally.

Syphilitic Ulceration of Throat.—Iodine liniment or iodoform externally, and the tincture or iodide of potassium internally, are very serviceable in this condition.

Chancre—Bubo.—M. Lailler, in a large experience at the Hôpital Lourcine, found iodoform a most useful dressing for all forms of venereal ulceration (*cf.* Lancet, ii., 1878). Mr. Berkeley Hill adopts it as an almost invariable treatment of "specific

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sores;" also Profeta, Sheen, and others (Med. Times, i., 1875; Practitioner, i., 1879), and Dr. W. Cottle has observed chancres heal more rapidly under this remedy than under many others (B. M. J., i., 1878).

If secretion is abundant, *the sore should be cleansed* and dressed twice daily with the finely-powdered crystals, or an ointment containing iodoform. Smarting may be caused at first, but this and the pain of the disorder soon subside, and healing often takes place in a week or ten days. The unpleasant odour of iodoform is, however, a drawback to its use, and its results are not always so satisfactory as described above.

Gonorrhœa.—Gonorrhœal attacks in females can sometimes be cut short by one or two paintings of the vagina, cervix uteri, labia, and urethral canal with strong tincture of iodine, after first cleansing away the discharge. The pain lasts for some hours, but the result usually is good.

Purulent Ophthalmia.—M. Boinet relates a severe case of double ophthalmia and scrofulous catarrh, which had lasted for thirteen months when admitted into the St. Louis Hospital, but was relieved and, in a few weeks, cured by the constant employment of an iodine lotion and nasal injection. I began to use this treatment in such cases many years ago, and often had excellent results.

Keratitis—Photophobia.—In ulceration about the cornea, and in granular lids, iodine tincture is a good application; and the liniment, painted round the eye, relieves the photophobia so frequent in scrofulous children.

Otorrhœa—Aural Polypus.—Dr. Cassells (Glasgow) states that iodoform is very useful in these conditions, and in granulation from the membrana tympani, and caries affecting the meatus.

Catarrh.—The vapour given off by powdered camphor sprinkled with tinct. iodi has been found effective for arresting coryza (Med. Times, i., 1874); and inhaling from pure iodine, or carbolate of iodine, is also commended. The latter has been introduced as a patent remedy.

Ozæna.—In this obstinate disorder, and in various cases of post-nasal ulceration and discharge, the local use of iodoform has been much commended by specialists. Mr. Woakes, how-

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ever, found an ethereal solution very painful, and obtained good results with pledgets of iodoformed wool (B. M. J., i., 1878).

Erysipelas.—Several authors concur in stating that the local use of iodine tincture will relieve this inflammation.

Lanyon relates a case of idiopathic erysipelas, affecting the right side of the face and rapidly extending. The tincture was painted over and beyond the inflamed part; within four hours pain was relieved, and sleep obtained; the malady did not advance, and, after another application next day, convalescence set in.

Boinet records two cases of "traumatic" erysipelas—one connected with suppurating wounds in the perineum, and affecting the right thigh, the other starting from a varicose ulcer, and affecting the whole leg. Thorough application of iodine tincture, once daily for three days, rendered the wounds healthy, and controlled the inflammation and swelling. Dr. Davies is another advocate for the same remedy, used rather stronger (40 gr. iodine to 1 oz. alcohol).

Bartholow and others have not been so well satisfied with it, and care must be taken not to cause undue irritation by its use.

Burns—Chilblains.—In burns of the first degree and unbroken chilblains the pain, itching, and irritation may be relieved by iodine tincture, liniment, or ointment.

Lupus.—In erythematous lupus, and in early stages of the tubercular and markedly strumous forms, strong iodine paint is sometimes useful; equal parts of pure iodine and iodide of potassium, in two parts glycerine, may be used about twice weekly; this excites "substitutive irritation," and exerts some absorptive power, though I have not myself seen curative results from it. The plain tincture of iodine relieves the congested livid condition of the neighbouring skin if painted over it. Iodoform deserves a very careful trial (*v.* p. 112).

Acne — Sycosis. — Simpson recommended for indolent "menstrual" acne, a decolorized iodine paint made by mixing tinct. iodin. co. 1 part, with liq. ammoniæ 2 parts, to stand forty-eight hours (Med. Times, i., 1861). I have not found this preparation so effective as ordinary iodine when applied to glands, etc., and for acne there are several better remedies. The ointment of iodide of mercury is more valuable in acne rosacea, and that of iodide of sulphur in indolent acne and sycosis.

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Psoriasis.—In patches of obstinate chronic psoriasis the ointment of green iodide of mercury, or of iodide of sulphur, is very useful. I can speak well especially of the former, made in the proportion of 1 part to 8 of simple ointment. The effects are often more rapid and decided than those of tar ointment. Occasional alkaline or vapour baths should be used during the treatment.

Pityriasis Capitis—Alopecia.—In branny, scaly conditions of the hairy scalp, and in partial falling off of the hair from debility, painting with iodine tincture acts as a useful local stimulant. It should be combined with other treatment, such as soap frictions.

Pruritus.—In many varieties of this disorder—pruritus pudendi, pruritus senilis—iodine tincture locally applied often gives much relief.

In a case of hyperæsthesia of the vulva, without local lesion, but with severe "dyspareunia," powdering with iodoform rendered the parts quite insensitive to pain (Tanner). A tampon of iodoform had good results in another case.

Tinea Tonsurans.—In simple recent cases of ringworm affecting the body or the scalp, a few applications of iodine tincture or liniment may suffice to cure, but they seldom succeed in an aggravated case. The preparation introduced by Mr. Coster ("Coster's paste") is, however, more powerful. It is a solution of 1 part of pure iodine in 4 of "colourless oil of tar," and requires to be mixed carefully, for heat is developed during the combination; the resulting thick, dark-coloured liquid should be thoroughly painted over the affected part and allowed to form a crust, which may remain for seven to ten days. One or two such applications will often cure, but to say that they do not cause pain is a mistake. The pain has seemed to me about equal to that caused by the iodine liniment, which is sometimes severe.

THERAPEUTICAL ACTION.—*Internal.*—Iodine and the iodides have a similar action; the former is more stimulant to the general system, but more irritant to the gastric mucous membrane. It is probably better adapted for slowly modifying the general constitutional state, as, for instance,

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in struma; whilst the alkaline iodides, being more quickly passed out of the system, act better where some foreign material needs elimination, *e.g.*, in syphilis, lead-poisoning, or rheumatism. Practically, however, the much less irritant effects of the alkaline compounds indicate, independently of other considerations, their employment in the majority of cases for which iodine in any form is needed.

Metallic Poisoning.—Melsens found that every mercurial compound was soluble in an alkaline or neutral solution of iodide of potassium, and that corrosive sublimate, for instance, if fixed in a muscle, tendon, etc., could be dissolved out of the organic tissue by soaking it in such iodide solution. Also, that even metallic lead was, to some extent, soluble in the same medium, with formation of a double iodide of lead and potassium (Med.-Chir. Rev., i., 1853). Hence, he argued that in cases of mercurial or lead-poisoning, with salivation, tremor, colic, palsy, etc., iodides introduced into the blood could form soluble compounds with metal deposited in the tissues, and enable this to be taken up by the absorbents and passed out by the kidneys and other channels of excretion. Support has been given to this argument by the fact that an insoluble salt of mercury or lead may be given to animals without evident effect until after the administration of an iodide, when the recognized symptoms of poisoning appear. Further, we know, clinically, that sometimes in metallic cachexia, when active symptoms are no longer present, and the poisons are not detectable in the secretions, if an iodide be given, acute mercurial or lead-action may be developed, and the foreign substances may be found in the urine, etc.

Only *chronic* conditions of illness, such as palsy or cachexia, may be present when the iodide is commenced, but in the course of a few days *acute* symptoms, such as colic or salivation, may be reproduced until elimination is complete. But however the theory on the subject may stand, there can be no doubt that iodides often act well in plumbism, and, although I have not always succeeded with them, I have had some good results. The case of M. Faure, recorded by himself, is a good illustration of their value: engaged in white-lead manufacture, he suffered severely from the ordinary symptoms of plumbism,

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and cured himself with iodide of potassium. He remarks that he could tolerate the drug better when he took it *before*, than *with* food, which he attributed to the "fasting stomach being coated with mucus" (Med. Record, 1876).

Dr. H. Thompson has given the details of a case of plumbism, in which iodide of potassium, on three or four occasions, led to relapse of colic at the same time that iodism was developed, and these attacks were always followed by improvement in the paralysed extensor muscles, as if some of the metallic poison had been eliminated, though there is not a record of its detection in the secretions (B. M. J., i., 1871). Jacobs thinks the best results are obtained with the iodide in conjunction with emetic and purgative treatment (Med. Record, 1877).

Syphilis.—It is probable that iodine acts in this disease, much as it does in metallic poisoning, by assisting the elimination of a morbid material. It has been maintained indeed by Dr. Basham and others, that its influence is best seen in cases which have been previously treated by mercury; and Dr. Budd and Dr. Garrod have given instances in which mercurial influence was dormant until excited by the administration of iodides, when profuse salivation occurred, and recovery ensued. But there can now be no question that the drug has curative powers of its own, independent of mercurial action; they are evidenced especially in the later, or tertiary stages of constitutional syphilis, when either the mucous membranes are affected, as in deep ulceration of the fauces, or the bones are attacked with periostitis or nodes, or the skin suffers with rupial or lupoid eruption, or the brain-membranes are thickened, or gummatous deposits are formed in any of the viscera. In such conditions it usually acts far better than mercury, although this latter drug is more advisable in some *eye-inflammations*, such as iritis; and again, in a certain proportion of undefined syphilitic cases, an iodide of mercury will give better results than either medicine alone.

By causing the absorption of deposits and thickenings in various parts of the body, iodides cure, at the same time, many secondary and dependent symptoms, such as nocturnal pains, neuralgia, paralysis, dulness of sense or intellect, and convulsive paroxysms. The dose of iodide of potash is a matter of much importance, and need be limited only by the susceptibility or

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idiosyncrasy of the patient, and the progress of the disease—it may vary from 1 or 2 gr., up to 60 gr., two or three times daily, and the best results have sometimes been obtained from heroic doses, when ordinary ones have failed.

Elliotson gave 30 to 60 gr., or more, for a dose (Lancet, i., 1832), and Ricord commonly prescribed the same amount. Sir A. Cooper, Drysdale, Pollock, and others, have given instances of the value of such quantities (B. M. J., and Lancet, 1867–68); and more recently Dr. Buzzard has pointed out the importance of large doses, especially in syphilitic affections of the nervous system (Lancet, i., 1873).

In **Hereditary Syphilis** I prefer mercurial treatment, though infants generally bear iodides well.

Mr. Berkeley Hill has stated that the iodide of ammonium or of sodium will sometimes cure when the potassium salt has failed, and this fact should be remembered in practice (B. M. J., ii., 1871).

Rheumatism.—Dr. Graves was one of the first to indicate the value of iodide of potassium in rheumatism, and it is now well established. I connect its efficient anti-rheumatic action mainly with an eliminant action through the kidneys, and to promote this, recommend it to be largely diluted and combined with bicarbonate of potash in acute cases. To prevent irritation of the stomach, the medicine may be given in an effervescent form. Sometimes if the patient be feeble, and the urine abundant and of low specific gravity, the iodide may be combined with hydrochloric acid and quinine, as recommended by Dr. Southey. When effusion has occurred into the pericardium or the joints, tincture of iodine or iodides are certainly indicated. In muscular rheumatism they are useful, especially in those cases where the pains are made worse by warmth. This is one character of periosteal and syphilitic pain, and possibly some of the good results obtained from iodide of potassium in cases of chronic painful joints, sciatica, and lumbago, may be explained by its removing a latent specific or mercurial, or other metallic taint. In cases of chronic rheumatism, small doses of iodide, continued for a long time, often act exceedingly well, but some patients are very sensitive to its physiological action, and need special care to secure its toleration (*v.* pp. 88, 121).

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Gout.—In chronic forms of gout the iodide will often relieve, as remarked by Mr. Spencer Wells, who recommends 1 or 2 gr. thrice daily, well diluted with water or seltzer water. In some cases the tincture acts better.

Chronic Rheumatic Arthritis.—In this condition, often considered incurable, I have known the tincture of iodine prove very useful when given in 3-min. doses thrice daily, and applied locally; in others, the good effect has been remarkable when given at the same intervals, but in doses of 10 to 20 min.

Gouty Psoriasis.—In this malady the iodide deserves trial. In one case of the "inveterate" form, and of twenty years' duration, recovery followed the use of 10 to 30-gr. doses. There was no history of syphilis, only some suspicion of it from the copper colour of the rash (Lancet, i., 1871).

Ague—Intermittents.—Iodide of potassium is stated to have proved very efficacious in intermittent fever (Amer. Journ., April, 1867; Med. Times, ii., 1872). The tincture of iodine is the "Elixir de Willebrand" used on the Continent in doses of 10 to 15 min., and it is said with success (B. M. J., ii., 1874).

Paralysis.—Cases of this disorder recorded as cured by the use of iodides were probably dependent on syphilitic deposits, or inflammatory, or rheumatic effusions pressing upon nerve-trunks. In such cases it is certainly possible for these remedies to produce the necessary absorption and consequent cure.

Muscular Paralysis, acute and general in character, has sometimes yielded to the iodides in a remarkable manner, as instanced in a case of Dr. Murchison's (Lancet, ii., 1867). The man, aged twenty-six, had gradual loss of power and wasting first of the left, then of the right limbs, and then of respiratory muscles, and apparently progressive paralysis, with moderate pain, and no cerebral symptoms: he got worse under iron, arsenic, and galvanism, but improved markedly under iodide. Another case is given in Med. Times, ii., 1863—both were connected, probably, with a spinal meningitis.

Cerebral Palsy is not usually treated by iodides, but Dr. Sieveking considers that advantage may be derived from their eliminant action after acute symptoms have subsided (Med. Times, i., 1857). They may act usefully by regulating

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and equalizing the circulation, as well as by aiding absorption of any inflammatory products.

Neuralgia.—In such cases, if of a syphilitic or rheumatic origin, iodine is useful; and in rheumatic sciatica the combination of iodide of potash with vinum colchici is often very effective.

Chorea.—Manson affirms that he has cured seventy-two cases of chorea by giving iodide of potash. Bardsley and Gibney make similar statements, but many of these cases would probably have come to a natural termination after six or seven weeks' rest, even without iodine. We are still much in the dark as regards the nature of chorea, and from a rational point of view iodine can only be recommended for it as likely to influence a scrofulous, rheumatic, or syphilitic taint.

Epilepsy.—Magendie stated that he had cured this disease by iodide of potash, and Franklin gave to a boy, aged eight years, as much as 180 to 300 drops of iodine tincture, and curiously enough the boy bore it well and was cured (Köhler).

It seems to me that the remedy can only serve in such cases if there be a syphilitic or rheumatic origin.

Struma—Rachitis.—In the different manifestations of these constitutional states, such as enlarged glands, tumid abdomen, indolent ulceration, ophthalmia, etc., preparations of iodine, and especially the tincture, are of proved value. But though they lead to disintegration of morbid deposit, they do not appear to assist renovation of tissue, and for permanent good results require to be supplemented by good food and hygiene. Hence, also, the combination with iron—iodide of iron—is an excellent form, and the conjoint use of cod-liver oil is very desirable. These remedies are invaluable in rachitis especially, and are usually well borne by delicate children when alkaline iodides are not. Simon, indeed, concludes that the latter ought not to be given at all under two years of age (Med. Record, 1876), and even the iodide of iron sometimes excites gastric and renal irritation, especially in some delicate children with fair skin, red hair, and enlarged throat-glands, so that it is desirable to commence its use in small doses.

I have been accustomed to give 1 to 3-min. doses of iodine tincture well diluted, and continued for a considerable time, in cases of struma, and can recommend this form of medication.

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The iodide of ammonium is said sometimes to have exceptional value.

Lupus.—I have mentioned the external use of iodine in the treatment of this disease (*v.* p. 105), and there is some evidence in favour of its internal employment. Thus, Mr. Gay records cases of lupus affecting the face—in one man for seven years, in a woman for twenty years—which yet got well under ½-dr. doses of iodide of potassium (Med. Times, ii., 1871). There was no obtainable history or distinct evidence of syphilis, though one cannot but suspect a syphilitic taint in such cases. I have never known iodides cure ordinary lupus, nor is it a common experience. Dr. Mackey has noted two cases, in one of which the nose was affected, in the other the nose and scalp; ulceration was deep, indolent, and slowly progressive, in spite of caustic treatment; discharge was but slight, crusts formed at the edges, and the cases resembled true lupus, except that there were no tubercles, and the patients (men) were between forty and fifty years of age when the sores commenced. Both recovered quickly under the influence of iodide of potassium and mercurial lotions, but although there was no history of syphilis, the probability remains in favour of its existence in similar cases.

Hydatid Cysts.—Dr. Tanner recorded a few cases in which these cysts wasted, and were cured under the *internal* use of iodide of potassium, and although the relation of cause and effect may be questioned, there is some evidence of its possibility, and it deserves further inquiry (Med. Times, ii., 1872).

Meningitis (? Tubercular).—I have had several cases of meningitis that derived benefit from iodides, given alone or in combination. In one, a child, aged six years, ill for eight days, insensible, with dilated pupils, dysphagia, paralysis of one side, and convulsive twitching, getting worse under previous treatment, improvement began soon after commencing iodide of potassium, which was given in 5 to 10-gr. doses every four hours, and 5 min. of tincture of belladonna midway between. Recovery ultimately ensued, and the boy is now sixteen years of age. In another case of mine, aged eight years, the child had pain, vomiting, delirium, unconsciousness, convulsion, dilated pupils, tetanic stiffness of the neck-muscles, grinding of teeth, difficult respiration, slow weak pulse, and every sign of fully-developed

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meningitis, yet recovered under iodide of potassium and belladonna, with occasional doses of aconite. Dr. Leared recorded a case of recovery under 5-gr. doses of iodide of potassium when other remedies had been used without relief. He was satisfied as to the diagnosis of "tubercular meningitis." M. Rodet has recently recorded a severe case in a girl of eighteen recovering under daily doses of 4 to 5 grammes, and considers failure due to insufficient dosage (Med. Record, May, 1879.) Other desperate, but successful, cases are on record (Edin. Med. Journ., 1841; Lond. Med. Gaz., 1842; Med. Times, i., 1859; Bulletin de Thérap., Aug., 1861, etc.); and M. Golfin (Montpellier) narrates three cases of this malady which recovered from the second or third stage under frictions with an iodide of mercury ointment to the scalp. (Hydrarg. iodid. virid., gr. ij.; Potas. iod., gr. iij.; Camphoræ, gr. ij.; Cerat. Galeni, gr. xxxij.)

In one child, aged four and a half years, the symptoms showed death to be imminent—the head was drawn back, the face pale, pupils dilated and immovable, swallowing power was lost, partial paralysis, convulsion, and profound coma were present; the pulse was scarcely perceptible. About forty hours after commencing the iodo-mercuric frictions urine flowed, and the paralysis and convulsion gradually lessened; in the course of four days only headache and stupor remained; and by the fifteenth day convalescence had set in (Gaz. Med. de Montpel., Feb., 1847). Niemeyer speaks favourably of iodic frictions in basilar meningitis. The degree of credence, however, to be given to such remarkable cases as the above must depend upon the accuracy of the diagnosis, for brain-congestion or brain-anæmia in children, and, still more closely, simple meningitis, may simulate acute hydrocephalus to some extent, and I have certainly seen improvement under local frictions with iodized ointment, and internal treatment by iodide, bromide, and belladonna.

Trousseau and many physicians of experience deny that the tubercular form is curable under any circumstances, and certainly a large majority of such cases end fatally. Dr. Wilks "has seldom seen any good results" (Med. Times, ii., 1868).

In one case of hydrocephalus Brainard practised injection of

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iodine into the ventricles many times, with temporary improvement, but the child ultimately died in convulsions.

Phthisis.—Chronic congestive conditions of lung following on acute inflammations are usually connected with the scrofulous diathesis,—pneumonic phthisis especially. In such cases, benefit may be obtained from iodine preparations. I prefer the tincture; but the iodide of iron, or the iodide of ammonium, is useful, according to the case.

In the more acute form of tubercular phthisis, when the patient suffers from loss of flesh, quick pulse, high temperature, pain, cough, dyspnœa, and nocturnal sweatings, the tincture, given every four hours, and inhaled, as well as applied locally over the chest, offers a chance of arresting or ameliorating the disease. In some cases under my care, this treatment appeared to check the disease.

In tubercular phthisis, in the absence of acute symptoms, I have seen benefit from iodine and iodides, but have sometimes noticed hæmoptysis following their use, and therefore recommend caution in cases disposed to hæmorrhage.

Earlier observers—Chevallier, Elliotson, Bardsley, and others—thought iodine really curative in consumption. It can certainly lessen pulmonary induration and modify the irritative conditions of the bronchial mucous membrane and the character of expectoration: in fact, I have seen most symptoms improve under its use, but this must be supplemented by hygiene and generous living. Dr. Cotton's experience at Brompton Hospital was not so favourable: weight was seldom gained under iodide of potassium—generally diminished; dyspepsia was sometimes induced; usually, no definite effect could be traced (Med. Times, ii., 1859). Dr. Julius Pollock, on the other hand, found the remedy very serviceable, and his patients gained weight under its use.

I have noted most benefit in cases of *chronic phthisis*, and especially when a syphilitic taint existed. Dr. B. W. Foster suggests that it acts by stimulation of the pancreas, thus promoting assimilation of fatty food, and Claude Bernard proved its elimination by that gland. Iodine-inhalations in phthisis have proved of great value in my experience, exerting a disinfectant, and to some extent a resolvent, action. It is important to

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guard against soreness of mouth and undue irritation of the air-passages during their use.

Bronchitis.—In the subacute and chronic stages, iodide of potassium, or of ammonium, relieves by an alterative action on the bronchial mucous membrane, thinning and ultimately diminishing the semi-purulent tough secretion. They may sometimes with advantage be combined with anti-spasmodics and other expectorants. In weakly subjects, the iodide of ammonium, in doses of from 2 to 5 gr. every four hours, may act better than the potassium salt. When there is an increase of temperature, aconite also should be given in doses of from 1 to 3 or 5 min. every two to four hours. If an expectorant is required, tartar emetic should be chosen. The dose should be small and frequent, and care should be taken to avoid emesis. With ordinary precaution in the regulation of the dose, neither aconite nor antimony need be dreaded for their depressing action, and it is remarkable how favourably these medicines act in conjunction with iodides.

Asthma.—I have known iodide of potassium relieve many asthmatic patients, and Horace Green (1860) found it to be the main ingredient in a secret and successful remedy for asthma. Trousseau and Jaccoud speak of its value, and M. Sée records valuable observations upon twenty-four cases watched for a long time. Four of these were children, four old people, the others adults; the daily dose varied from 22 to 45 gr., it being reduced as improvement progressed: if given some hours before the usual attack this was often prevented; if given during it, respiration was rendered free in one to two hours. Chronic asthma with emphysema was also benefited by the remedy; inhalations of iodide of ethyl, six to ten drops several times daily, and the occasional use of opium or chloral in these latter cases, were with advantage conjoined with the treatment (Med. Record, 1878). Dr. Hyde Salter has observed benefit from iodide of potassium in full doses—15 to 30 gr.—every two to four hours, in very diverse cases of asthma. I think that such attacks as are connected with catarrh, and are relieved by free secretion, and in which the nerve-symptoms are reflex, rather than primary, show the best results from this remedy. I have known it efficacious in asthma connected with amenorrhœa and uterine congestion, and also in

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the asthma of rheumatic and gouty subjects. In an interesting case in a very rheumatic patient, the asthmatic attack was relieved by 4-gr. doses of iodide, but severe pain in the region of the kidney followed, with secretion of scanty acid urine; this occurred more than once, and was only relieved by free excretion of alkaline urine under appropriate remedies (B. M. J., Jan., 1875). In this case, the drug was supposed to cause renal congestion by increasing the absorption of waste nitrogenous material, and consequently the amount to be eliminated. I have known iodine itself produce renal congestion in some individuals.

Dr. C. J. B. Williams has seen a very large number of asthmatic cases relieved by iodide and by carbonate of potash with stramonium (Med. Times, i., 1872), but most of M. Sée's cases were relieved by the iodide alone. Dr. Reed recommends the liquor iodinii in "dry asthma" of constitutional character and without obvious exciting cause (Med. Record, 1879).

I believe that the drug acts directly on the mucous membrane, relieving its congested state by promoting a thin fluid secretion, but independently of any theory, it will be found worthy of trial in any rebellious case.

Catarrh.—Iodide of ammonium, in 1-gr. doses every two to four hours, is a good remedy in ordinary acute catarrh.

Hay-Asthma.—In this distressing malady, iodide of ammonium, combined with arsenic, will often give a better result than either remedy alone. Weak iodine solution should be injected into the nares, or, what is more convenient, the vapour of iodine or of carbolate of iodine should be inhaled by the nostrils, as recommended by Melville (Lancet, ii., 1864).

Sore Throat.—In cases of follicular tonsillitis, or when spots of ulceration about the buccal mucous membrane are induced by cold, small doses of iodide are useful.

Croup—Diphtheria.—The tincture of iodine as well as the iodides are very valuable in these disorders, especially in their early stages; they should always be given in conjunction with aconite, and occasionally the judicious use of an emetic is serviceable. I trace the benefit following the use of the iodide partly to a local effect, rendering the false membrane less tenacious, and partly to an eliminant action on the kidneys. Its use by

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inhalation has already been mentioned and should be strictly attended to (*v.* p. 94).

Albuminuria.—The prolonged administration of iodide of potassium in chronic Bright's disease is said to have retarded fibroid changes in the kidney, and induced general improvement in nutrition (Bartholow). Dr. Créqui (Brussels) recommends it for the second or parenchymatous stage. Using commonly 6 gr. or more daily, he has sometimes given as much as 6 dr. in the day, with bismuth or opium to control irritative effects. He presumes the iodide acts by limiting morbid secretion in the renal tubules (Lancet, i., 1871). In subacute cases, with dropsy, I have frequently used this remedy in doses of 3 to 4 gr., and have seen apparent advantage from it. I think it hastens absorption of inflammatory products, but from what has been already stated as to the possibility of its causing renal congestion (*v.* p. 87), it must be considered unsuitable in acute nephritis, unless in fractional doses.

Ascites—Anasarca.—Not only in renal dropsy, but in that dependent on hepatic disease, and certainly in general anasarca independent of organic malady, iodide of potassium or iodide of iron is useful. Frictions with iodized liniment should be combined with the internal treatment. Injections have sometimes been used (*v.* p. 97).

Aneurism.—In those cases of thoracic and abdominal aneurism, in which surgical treatment is impossible or highly dangerous, the clinical results obtained by iodide of potassium should not be ignored. Nélaton recorded marked relief to the signs and symptoms of an innominate aneurism under the use of this remedy, which he gave empirically at the request of the patient, and Bouillaud, following up this clue, obtained good results in aneurisms of the carotid and thoracic vessels (Med. Times, i., 1859).

Chuckerbutty, in Calcutta, published three cases relieved, in one of which the aneurism was already projecting through the sternum when the drug was commenced, and Dr. W. Roberts and Mr. Windsor recorded some equally striking results about the same time (B. M. J., ii., 1862; i., 1863).

It is, however, to Dr. Balfour that we are most indebted for drawing professional attention to this subject (Edin. Med. Journ.,

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1868–69). He summarizes 15 cases, all of which, save one, were relieved, and in 12 the external tumour was actually lessened and the sac partly consolidated. In one of his earliest patients the bulging, which was evident between the second and third ribs, disappeared after a few weeks' treatment with 30-gr. doses thrice daily, and this dose was continued for nine months "without any unpleasant symptoms," but with complete subsidence of aneurismal suffering. The same man had not improved under previous doses of 20 gr., and Dr. Balfour points out the importance of pressing the drug to saturation before considering it inert. It is very quickly eliminated—large doses within two or three days—and many of his patients took 20 to 30 gr. several times daily. In a few, coryza and headache were quickly induced, and 5 gr. only were tolerated, but, as a rule, no worse symptoms were caused by large than by small doses. Additional evidence in favour of this treatment has been furnished by Dr. W. Roberts, Dr. Shapter, and others (Med. Times, 1874; B. M. J., 1873–74), and recently Dr. Philipson has reported a cure of an abdominal aneurism (B. M. J., i., 1878).

It seems to me no argument against such cases to say, with Dr. Bristowe, that any remedy which coagulates the blood in an aneurismal sac must tend to coagulate it elsewhere, and is therefore inadmissible; or to note with Mr. Holmes that aneurism may sometimes develop in patients already under the influence of iodide (Med. Times, i., 1872). This is only saying that the remedy is not infallible, and that its mode of action, whether on the composition or vital condition of the blood (Chuckerbutty, Roberts), on the nervous system (Balfour), or on the walls of the sac, is not yet clear. I have myself seen remarkable advantage from its use, and suggest in addition to the above explanations, a possible anti-syphilitic effect—for the occasional connection of syphilis and aneurism is sufficiently proved by modern research.

Chronic Inflammatory Indurations.—In simple chronic enlargement of glandular organs, the liver, the spleen, the mammary gland, or the testes, iodine is often of more service than any other medicine. The cause may be syphilis, struma, or malaria, and yet the same remedy be applicable.

I generally recommend 1 to 5 min. of tincture thrice daily

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for a long period, though sometimes iodides are better borne. External painting, or iodine compresses, should be used at the same time. Iodoform ointment, or iodoform collodion, is also to be highly recommended (*v.* pp. 90–94).

Bronchocele.—In simple soft goître, in which malady, indeed, the reputation of iodine was first acquired, I consider it almost a specific. In recent cases, 1 to 5-min. doses of the tincture produce the best results, for if unduly large quantities be given, the swelling becomes hard, tender, and painful. In more chronic cases already indurated, large doses—¼ to 1 gr. of iodine—may be given in conjunction with its external use (*v.* p. 92): some astringent syrup, *e.g.*, of cinchona or orange peel, should be added to prevent derangement of stomach. Mr. Bryant has known goîtres rapidly disappear under the influence of an iodized atmosphere obtained by simply placing iodine in a perforated box in the patient's room; he recommends also the local use of an ointment of iodide of ammonium (Practical Surgery, 3rd Ed.).

In **Exophthalmic Goître** I have also seen a limited amount of success from the internal use of iodine tincture, the palpitation being frequently relieved by small doses.

Uterine Fibroma.—Fibroid growths or indurations, especially those originating in the cervix, *i.e.*, in the more glandular and secretory part of the uterus, often improve under the use of iodine or iodides. Dr. Ashwell long since described them as "melting down" under this treatment (Guy's Reports, vol. i.), and mineral waters, of deserved repute in such cases, owe their efficacy to a combination of iodides and bromides (*v.* p. 153).

Direct injection of the drug into the growth is also a valuable resource with due precaution. I have injected 10 to 20 min. of an aqueous solution of iodine (half the strength of the B.P. tincture) in twenty-three cases of uterine fibroids, of large size, and repeated the operation several times with encouraging results. Nearly all improved considerably under the treatment, and the tumours disappeared in five instances, within twelve months of the first injection. Two cases suffered considerably from local inflammation, obliging the treatment to be discontinued after the third and fourth injections respectively, but both these cases eventually improved more quickly than any of the others.

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In **Passive Uterine Congestion** tincture of iodine is often useful; and Dr. J. B. Schmidt has written to recommend minim doses for chlorotic subjects suffering from headaches, frequent menstruation, and diarrhœa (Med.-Chir. Trans., i, 1871).

Amenorrhœa—Sterility.—When these conditions depend on functional causes, congestion, torpor, debility, etc., iodine and the iodides are useful. I have often proved them so in the former condition, and sometimes in sterility they exert a stimulating effect on the uterus, possibly because of their elimination by the mucous membrane.

Vomiting of Pregnancy, etc.—I have known 1 to 5-min. doses of the tincture arrest the capricious vomiting, also the pyrosis and heartburn of pregnancy, possibly by a stimulant effect on the gastric membrane. Its local application to the cervix, conjoined with its internal administration, often acts with advantage. Dr. Eulenburg recommends 10-min. doses as very serviceable, but I prefer the smaller doses repeated every two or three hours.

Atonic Diarrhœa, Dysenteric Diarrhœa, etc.—I have obtained benefit from similar doses in atonic diarrhœa, and in the form which occurs during phthisis. They have been recommended in cases of passive hæmorrhage and serous intestinal flow, dependent on "paralysis of the ganglionic centres" (Schmidt, Med.-Chir. Rev., i., 1871); also in later stages of typhoid fever. Iodized enemata have been used in dysentery to relieve tenesmus (Med. Times, i., 1857); 1 to 5-min. doses of the tincture, given every four hours with cinchona, will cure the tormina and the tenesmus of dysenteric diarrhœa.

PREPARATIONS AND DOSE.—*Tinctura iodi* contains iodine ½ oz., iodide of potassium ¼ oz., rectified spirits 20 fluid oz.: dose, 5 to 20 min. *Liquor iodi* contains 20 gr. iodine, 30 gr. iodide of potassium, in 1 oz. water: dose, 3 to 10 min. *Linimentum iodi* contains iodine 1¼ oz., iodide of potassium ½ oz., camphor ¼ oz., rectified spirit 10 oz. *Unguentum iodi:* iodine 32 gr., iodide potash 32 gr., proof spirit 1 dr., prepared lard 2 oz. *Vapor iodi* (inhalation of iodine) contains tincture of iodine 1 dr., water 1 oz.: heat slightly for inhalation of vapour. *Iodoformum:* dose, ½ to 2 gr. in pill, or pastilles—as made by Messrs. Bullock,

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containing 2 gr. in each (Med. Times, ii., 1878). *Unguentum iodoformi:* 1 part in 8. *Collodium iodoformi:* 1 part in 16. A *suppository* containing 20 gr. with cacao butter is officinal in the German Pharmacopœia. *Potassii iodidum, sodii iodidum:* dose, from ½ to 30 gr. and upwards in syphilis; average dose, 3 to 5 gr. The dose of the *ammonium* salt is somewhat smaller.

ADMINISTRATION.—Opinions are still divided as to the best time for giving iodides with relation to food.

Dr. Parkes and others recommend them to be taken before meals, in order to prevent decomposition by acids, and to secure dilution with mucus. Some give them at bedtime in effervescence; and again, others find them better borne by a full stomach. All agree that they should be freely diluted, and not taken when there is much starchy food in the stomach, and if there are not febrile or acute gastric symptoms, a bitter infusion or tincture is a good vehicle; in other cases milk is very suitable. Large doses sometimes produce less iodism than small ones (Althaus), and arsenic is to some extent corrective of the unpleasant results (B. M. J., ii., 1871). Ethereal oil, such as that of peppermint, diminishes the mal-odour of iodoform (Med. Record, 1879).

ADULTERATIONS.—The iodides sometimes contain iodates of the respective alkalies, and not unfrequently an excess of water, and after keeping, free iodine is developed to some extent (*v.* p. 76); but of six chance specimens analyzed all were found pure (B. M. J., ii., 1870).

BROMUM—BROMINE, Br, = 80.

This element is contained in sea-water and in some saline springs, as in those of Ashby, Birtley (Durham), Woodhall, and Kreuznach, also in seaweed and in molluscs.

PREPARATION.—Bromine is chiefly obtained after the crystallization of common salt, from "bittern" or sea-water (in which

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it exists as bromide of magnesium, sodium, and potassium), by passing through the liquid, chlorine gas, which sets free the bromine. The mixture is then shaken up with ether, which dissolves the bromine and rises to the surface and is decanted. To this ethereal solution caustic potash (or soda) is added, and the ether evaporated off by heat. The crystals of bromide of potassium thus obtained are treated with sulphuric acid and manganese oxide, and the liberated bromine is evaporated and collected in cooled receivers.

The reactions are:—(1) $MgBr_2 + 2Cl = MgCl_2 + 2Br$. (2) $6Br + 6KHO = 5KBr + KBrO_3 + 3H_2O$. (3) $2KBr + 3H_2SO_4 + MnO_2 = 2KHSO_4 + MnSO_4 + 2H_2O + Br_2$.

The potassæ bromas ($KBrO_3$) formed in the second reaction is converted into potassium bromide (KBr) by ignition before the final process.

CHARACTERS AND TESTS.—Bromine is the only non-metallic element which is liquid. It is of brownish-red colour, very volatile, and emits an irritating, very fœtid vapour, whence its name Βρωμος, a stench. It boils at 145·4° F. (Pierre) (139·1° F. Bolas and Grove), not 117°, as stated in the B.P. Iodine, chlorine, and alkalies decolorize bromine, with formation of bromides and bromates, and in contact with hydrogen-compounds it forms bromhydric acid. Solutions in alcohol and ether (which liquids dissolve bromine readily) lose their colour in a few days with formation of the same acid. Bromine should be kept in a stoppered bottle, and under water, in which it is only slightly soluble. At 32° F. it forms with water a crystalline hydrate.

PHYSIOLOGICAL ACTION.—Bromine coagulates albumen and combines with it in a definite proportion of Br. 23, albumen 96, which compound is soluble in caustic potash, and is colourless (Glover, Harveian Essay, 1842).

Undiluted bromine quickly oxidizes and destroys organic tissues, forming a brownish slough. With fatty substances hydrobromic acid is developed. Bromine vapour is intensely irritating to the air-passages, possibly on account of its liberating free ozone on contact with moist mucous surfaces exposed

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to air. It may cause coryza, or even laryngitis, bronchitis, or pneumonia, and may destroy the sense of smell.

When taken internally in doses of 1 to 2 drops, well diluted, it has a taste "truly horrid" (Glover), and causes weight and heat at the stomach, often colic, shooting pains in the limbs, and itching in the extremities; but after an hour or so these symptoms are succeeded by a general sense of comfort and stimulation. Larger doses may cause gastritis with symptoms of intense irritation, prostration, and collapse. Independently of this *local irritant* effect, the physiological action of bromine, after absorption, is exerted mainly on the *lymphatic* and *glandular* systems, their functional activity being increased.

Köhler mentions several experiments which have been made with bromine, and says, "that, independent of its local irritant action, it exerts, if taken in small doses for some time, a strong action upon the brain, viz., depression of the mental functions, sleepiness, stupor, prostration, and a state resembling alcoholic intoxication." On the other hand, bromine does not show the peculiar depressing action of its potash salts on the heart, nor their special effect on the spine, of lowering its reflex irritability.

THERAPEUTICAL ACTION.—*External.*—**Hospital Gangrene—Erysipelas.**—The value of bromine as an escharotic and caustic in these maladies was conclusively shown during the American civil war by Surgeon Goldsmith. The formula commonly employed was—"bromine 1 oz., bromide of potassium 160 gr., water 4 oz." After thorough cleansing of gangrenous wounds this was applied; and, although very painful for a time, the pain was mitigated by bathing, and the malady was arrested better by this than by any other means (Med. Times, ii., 1863, 526). The same application was found valuable in diphtheria and erysipelas, and the liquid, when exposed in shallow vessels, served also to disinfect hospital wards.

Mr. Marshall and Mr. Southam used a solution of 1 scruple of bromine in 1 oz. of spirit for unhealthy wounds, and found it useful, but very painful; its offensive smell is also a drawback to its employment (Med. Times, ii., 1868, p. 93). The pure drug has also been applied, and acts well in similar cases, but requires

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special precaution to carry the vapour away from the patient (Lancet, ii., 1868).

Chancre—Epithelioma.—In the few cases where a chancre can be, with advantage, destroyed in an early stage, bromine is one of the most efficient agents for the purpose.

Dr. Wynn Williams and others have reported very satisfactory results from the use of local bromine injections into the substance of epithelial cancer affecting the cervix uteri (Med. Times, ii., 1866, p. 488, and ii., 1870, p. 255). Dr. Williams uses a solution of 12 min. in 1 dr. of rectified spirit, injecting it through a speculum by means of a long glass syringe having a platinum point (the nostrils of the operator should be plugged with cotton wool). There can be no question of the good results obtained by Dr. Williams, but as he restricted his method to cases "in which the uterus was not fixed," some doubts were thrown on the diagnosis of cancer by Dr. Playfair and others.

Strumous Glands—Chronic Skin-Diseases.—Ointments and lotions containing bromine have been applied to glandular swellings and ulcerations, and to patches of chronic eczema, with moderate success (Bonnet, Bulletin de Thérap., 1837), but severe symptoms of irritation of lungs and stomach have sometimes followed, and iodine applications are more generally adopted.

Nasal Catarrh — Hay-Asthma—Ozæna. — Brominized inhalations are of value in these disorders, and may be employed in the manner recommended by Bartholow. Half a drachm of bromine is mixed with four ounces of alcohol, and a small quantity of this placed in a wide-mouthed phial and vaporized by the warmth of the hand, furnishes a diluted vapour which should be drawn up into the nasal passages.

Diphtheria—Membranous Croup.—Brominized inhalations and external applications have been successfully used, especially by German physicians in these maladies, and in diphtheritic vaginitis (B. M. J., ii., 1872). Ozanam used also an aqueous solution internally (Brit. and For. Rev., April, 1869), and I have myself seen excellent results with this combined method of treatment, diphtheritic membrane disappearing under it. I have employed the inhalations and bromine internally every three or four hours, using one or two drachms of a solu-

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tion containing eight drops to the ounce, even when the disease had extended to the bronchi, and great prostration had set in, and sometimes I have used the vapour and local applications of bromine whilst giving iron internally, also with very good results.

Redenbacher has reported two successful cases in which bromine and bromides were useful (B. M. J., i., 1879).

THERAPEUTICAL ACTION. — *Internal.* — Chronic Arthritis.—Andral treated this disorder by giving bromine at first in 2-drop doses, but later with as many as 60 drops in twenty-four hours. The gastric irritation, however, was too severe to make such treatment desirable.

Struma.—Bonnet recommended 5 to 10 drops daily in cases of glandular scrofulosis, conjoining local applications (Bulletin, 1837), but the internal use of bromine is practically superseded by that of its compounds. It is possible, however, that smaller and more frequent doses of bromine than have hitherto been prescribed might give better results, with avoidance of gastric irritation.

COMPOUNDS OF BROMINE.

POTASSII BROMIDUM—BROMIDE OF POTASSIUM, KBr, = 119.

PREPARATION.—By adding bromine in slight excess to liq. potassæ, and afterwards heating with charcoal, dissolving, and crystallizing. In the first part of the process a mixture of bromide and bromate of potash is formed, $6KHO + Br_6 = 5KBr + KBrO_3 + 3H_2O$, and in the second part the bromate is deoxidized, the bromide remaining unaffected.

CHARACTERS AND TESTS.—It occurs in cubical crystals, resembling those of the iodide, but smaller. When well kept they are transparent or white, but commonly have a tinge of yellow from some free bromine. They have a saline, bitter taste, and high diffusion power. They contain 66 per cent. of bromine. Chlorine water added to the crystals liberates bromine, which will impart an orange-red colour to chloroform, ether, or sulphide of carbon. The starch test would detect iodine, which used to be a frequent adulteration.

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AMMONII BROMIDUM—BROMIDE OF AMMONIUM, NH_4Br, = 98.

PREPARATION.—By saturating hydrobromic acid with ammonia—$HBr + NH_4HO = NH_4Br + H_2O$.

CHARACTERS AND TESTS.—It occurs in white, colourless crystals, which gradually become yellowish; is rather more disagreeable to the taste than the potassium salt; answers to the tests mentioned, but effervesces with acids.

Sodii Bromidum—Bromide of Sodium, NaBr (not officinal). Crystallizes like the analogous salt of potassium; it is less bitter in taste; contains more bromine (78 per cent.).

Lithiæ Bromidum—Bromide of Lithia (not officinal), is crystalline, white, soluble, and contains a larger proportion of bromine than any other compound (92 per cent. Weir Mitchell).

Calcii Bromidum—Bromide of Calcium (not officinal), is white, very soluble, in fact deliquescent. Readily decomposes on exposure, becoming brown in colour: occurs in Kreuznach and Vals water: is less stable than the potassium salt, and therefore more active (Hammond).

Magnesiæ Bromidum—Bromide of Magnesia. This salt is the main source of the metalloid, and is especially abundant in the water of the Dead Sea. It is found also in the Ashby and Kreuznach waters.

Besides these, there are many *metallic bromides*, such as those of iron, zinc, mercury, and lead; and many *organic bromides*, such as those of camphor, morphia, quinine, and strychnia. Their properties are chiefly those of the base, but modified somewhat, so as to act more favourably on the nervous system. *Bromhydric acid* is another combination recently introduced (B. M. J., July, 1876) (*v.* p. 151). *Hydrobromic ether* is said to be an efficient and comparatively safe anæsthetic (Levin).

ABSORPTION AND ELIMINATION.—The alkaline bromides are readily absorbed, and have been found in the urine and saliva five minutes after a dose of 15 gr. (Rabuteau); in ten

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minutes' time the reactions were very manifest. Bowditch drew blood from the carotid of an animal six minutes after 10 gr. had been taken, and calculated that even in that time a third of the dose had passed into the circulation (Boston Journ., Oct., 1868). They are usually eliminated *unchanged*, and Voisin has obtained cubical crystals of the potassium salt from the urine of patients taking it. The rate of elimination varies. In some experiments already mentioned, the urine gave traces of the drug in ten minutes; in others thirty minutes was the earliest period, in others twenty-five hours (Bowditch). The excretion of single large doses is usually complete in one or two days (Chauvet, Amory), though minute quantities have been detected in the urine for three or four weeks afterwards (Rabuteau). If the drug has been taken continuously for some time, the period of its excretion is prolonged: thus Namias found it continue for fourteen days (Gaz. Hebdom., 1868), and renal disease so far impedes its excretion that upwards of thirty days may be required for its completion. Dr. Stevenson "detected bromides in the urine of a child passed about four weeks after the medicine was discontinued" (Lees, Path. Soc. Trans., 1877).

As evidence, also, of the slow elimination of these salts, Drs. Crocker, Lees, Barlow, myself, and others, have noted the increase, or even the chief development, of the rash sometimes produced by them, after the discontinuance of the drugs. The elimination of bromides is certainly *slower* than that of iodides. It occurs not only by the kidneys and the saliva, but also by the mammary, lachrymal, and sudoriparous glands, and by mucous membranes—by the last especially in the case of the ammonium salts. In exceptional instances, the salts have been decomposed in the system, and free bromine eliminated in the breath. The alkaline compounds do not usually pass by the fæces unless diarrhœa occur; but if *metallic* bromides be taken, the *metal* passes chiefly by the bile and the motions.

Thus, when experimenting with bromide of iron, Namias found bromine abundantly in the urine, but iron scarcely at all. The same observer, examining the body of a man who died whilst taking bromide of potassium, found that salt in all the fluids, as well as in the brain, liver, lungs, and

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other viscera (Comptes Rendues, Tome lxx.). After very large doses, an unabsorbed portion has been found in the intestine.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Doses of 5 to 15 gr. of the alkaline bromides are well borne by the stomach, but upwards of 20 or 30 gr. will often cause irritation and nausea, with sense of weight and coldness, or later of warmth. At first the gastric secretions are rather lessened and appetite slightly increased, but after a time there is anorexia, and gastric catarrh and diarrhœa may occur, especially with the potassium salt. Bromide of sodium increases thirst as the chloride does. The sensibility and the reflex movements of the *fauces* and *pharynx* become much lessened under the full influence of the bromides, and even from their continued local application. If, however, these parts are inflamed, a strong solution may prove very painful.

Nervous System.—The action of bromides on the nervous system, especially of the lower animals, has been carefully studied by many observers, but with different and somewhat confusing results. Thus, whilst Damourette, Pelvet, and R. Amory conclude that the functions of nerve-tissue become paralysed by its direct local application (Bulletin Thérap., Tome lxxiii., and Essay on Bromide, 1872), Saison finds no trace of such paralysis (Du Bromure, Thèse, 1868); and whilst Laborde and Purser are satisfied that reflex function is early abolished (Archives de Physiol., Tome i., and Dub. Journ., 1869), Bill holds this to be unproven, and argues that results with frogs are but little guide to effects on men (Amer. Journ., July, 1868).

I believe, myself, that in this instance there is much analogy in the action of the drug on men and animals, and a careful consideration of the evidence before us warrants the following statements.

In *batrachians*, the bromides, when injected under, or absorbed through the skin, after producing spasm, exert a local paralysing effect on the neighbouring tissues, whether nervous or muscular. If the injection be made close to the brain or to the cord, the *centre* which is *nearest* will be paralysed

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soonest; but if absorption occur at a distance, *e.g.*, through the web of foot, then *reflex power* is *first* lost, so that pinching or irritation does not excite the usual contractions. The periphery of sensory nerves loses its sensibility very soon afterwards; then the motor tract of the cord and motor nerves are affected, and lastly the cerebrum. Most of the characteristic effects of the drug may be seen on frogs after the medulla is divided from the brain, but if it be left undivided, the persistence of some voluntary power, after the cessation of reflex function, is made evident by movements even after apparent death.

In *warm-blooded animals* the demonstration of early loss of reflex power is not so complete, but there is evident impairment of sensibility and of cerebral action, with partial paralysis, especially of the *hind* limbs.

In *man*, the earliest effects of *full* doses on the nervous system are usually seen in impaired sensibility, especially of mucous surfaces, such as the fauces and pharynx, the conjunctiva, and the urethral membrane. It is possibly most marked in these regions because the drug is largely eliminated there, but loss of tactile sensibility is also sometimes observed in the palms and the soles. Affection of the nerve-centres is shown, sooner or later, by languor, lassitude, and drowsiness; giddiness is complained of, and exceptionally there may be cerebral excitement; mental working power is temporarily impaired, so that ordinary accounts become puzzling, and memory fails. The amount of the drug that produces such symptoms varies in different persons. Dr. Lockhart Clarke has noted them from half-drachm and drachm doses, but usually they are not seen until after much larger quantities have been absorbed. The impaired nerve-condition is known as "bromism," and when developed in an extreme degree, the special senses, sight and hearing, are greatly dulled, reflex and motor power are almost wholly lost, and the cerebral state is one of absolute apathy and indifference bordering upon idiotcy. As a rule, these serious symptoms subside quickly on omission of the drug.

In a case said to be of chronic bromine-poisoning there were vertigo, amaurosis, and some loss of co-ordination and sensation (Med. Record, 1879).

In seeking for an explanation of the *mode* of action of

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bromide it is clear that we must go further than the contraction of minute vessels in the nerve-tissue; we may grant that it produces, in certain doses, such a contraction, and may therefore believe that it irritates or stimulates vaso-motor nerves, but besides this, must be admitted, for toxic doses at least, a *direct* sedative depressing action on the cerebro-spinal system, both central and peripheral, and *in some instances*, the action on the vaso-motors is also paralysing, and is accompanied by relaxation of capillaries and local congestions. It is thus that we may explain the exceptional occurrence of diarrhœa or diuresis under bromides, and more particularly the retinal congestions found by Dr. Nicol after doses of ½ to 1 dr. (Med.-Chir. Trans., ii., 1872)—but this point requires further investigation.

Nothnagel says the temperature always goes down after large doses in men and animals—after 10 grammes (2½ dr.) by 0·5° to 0·8° C., after 15 grammes by 1·2° C. (Krosz).

Circulatory System.—In a frog, if strong solutions be injected near the cardiac region, the heart is suddenly arrested in diastole, but under a slower *distal* absorption this does not occur, nor is there evidence of the specific paralysing effect upon the heart contended for by Eulenburg. On the contrary, the heart has been found beating one or two hours after complete paralysis of the nervous system and of respiration (Damourette, Saison). The heart-action is rendered slower, but, as a rule, the capillaries are narrowed *before* this slowing. It is not the soaking through of the cardiac muscles by bromide of potash that produces these effects (as it does in the experiments on the frog mentioned above), but the gradual lowering of the spinal reflex irritability. The observers just named, as well as Meuriot, Hammond, and Amory have witnessed the narrowing of vessels in the web, the tongue, or the brain of frogs or dogs, but others have failed to see this, and Dr. H. C. Wood considers the present proof insufficient; neither does the observation that divided capillaries of a brominized frog bleed less than normal ones, seem free from criticism, for he suggests that lowered heart-action would account for lessened bleeding. But, these observations apart, I think the surface-pallor that follows the use of bromides, and the lessening of secretion and discharge, point strongly in

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the same direction (narrowing of vessels). There is also post-mortem evidence of lessened blood in capillaries when influenced by bromide (Saison), and we may quote, too, the clinical fact that bromides relieve many forms of *capillary congestion*, especially cerebral and uterine, whereas in patients with cerebral *anæmia*, the effects are often distressing. Thus, whilst Dr. Wood considers capillary contraction to be "somewhat probable," I hold it to be more clearly ascertained.

That the heart-action and the general circulation are slowed in the lower animals is also evident from many experiments (Damourette and Pelvet, loc. cit., and Schouten, Schmidt's Jahrb., Bd. cliv., p. 11). This is more marked with the potassium salt than with the others, and may be largely credited to the alkali; the bromide of sodium has comparatively slight effect in this direction (Eulenburg, Rabuteau). In man, the depressing effect of any bromides on the circulation is not constant; Pletzer noticed it (Schmidt, Aug., 1868), and Bartholow records a depression of 10 to 20 beats per minute after a dose of 2 dr., but Dr. Bill, Dr. Voisin, Dr. Russell Reynolds, and others have failed to observe such a result with doses of 20 gr. and upwards continued for some time. It is evident that circulatory depression is a less constant and characteristic effect of the bromides than nerve-sedation.

Generative System.—Speaking generally, we may say that bromides act as sedatives upon the genital system, and diminish the sexual feelings and the power of erection, though the secretion of the testicles is not lessened (Rabuteau). But we must recognize that genital excitement may arise either from *excentric* cause (as urethral irritation, rectal or ovarian congestion, etc.), or from a *centric* cause in the mind, cord, or brain itself. It is the former that is controlled by bromide, and there is some reason to think with Dr. Bill that its effect is *mainly* local, and exerted through the mucous membrane of the urethra, although, no doubt, some effect may be attributed to a lessening of congestion in the spinal cord (*v.* p. 146). The degree of sedation induced by bromides varies in different men and in male animals, and is shown only under the influence of large doses. It is said not to be exerted in the female sex, though there is clinical evidence of these medicines lessening uterine and ovarian congestion and irritation.

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Action on Secretion and Excretion.—The *primary* effect of moderate doses of bromide is to lessen most of the secretions (Bowditch and others), although, as a *secondary* effect, or after very large doses, they may be increased. There is no lachrymation, salivation, or catarrh from a pure salt, as there is from the iodides, for bromides are more stable, and although also eliminated by mucous membranes, do not part with free bromine on their surface. The mouth is rendered rather drier than usual, especially by the sodium salt. The amount of mucus in the intestinal canal is also lessened, so that constipation is not infrequent at first. The secretion of milk is lessened by the internal and local use of bromide of potassium (Tyler Smith, Med. Times, i., 1861). With regard to the amount of urine excreted, the usual result is that with small or moderate doses no increase can be made out, whilst with large or long-continued ones, diuresis occurs. Dr. Bowditch suggests that a *secondary* hyperæmia is determined more readily in the kidneys than in other parts, and Pletzer has reported albuminuria in some instances.

Bromides tend to lessen vesical irritability, and so to render micturition less frequent, though the amount passed may be really larger than usual. On the other hand, very large doses may so far paralyse the sphincter as to occasion incontinence.

Excretion of Urea and Carbonic Acid—Action on Nutrition.—From the experiments of Dr. Bill and Professor Rabuteau, it appears that tissue-change is *retarded* under the influence of bromides. The former especially noted that the carbonic acid eliminated was decidedly less than normal, and this independently of diminished nerve-power, and not proportionately to the dose, as it is with morphia and its congeners. For some time after ceasing the medicine the excretion of the gas was increased, implying that, for a time, "the way through the lungs was barred," and this he attributed to vital causes, "limited in their seat and effects to nerve-elements in the pulmonary mucous membrane."

Rabuteau found that whilst his average daily excretion of urea was 21·25 grammes, the mean amount passed whilst he took a daily dose of 15 gr. of bromide of potassium was 19·52 grammes; for a fortnight after omitting the drug it remained at

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about 20 grammes; in the third week it resumed a normal proportion, and in the fourth week exceeded this. Rabuteau connected the primary result with slowing of circulation and respiration: it was not accompanied by increased quantity of urine.

Dr. Gibb found the ammonium salt diminish body-weight "by favouring absorption of fat" (Lancet, i., 1863). If this be so, we should expect carbonic acid and urea to be increased in amount (contrary to the above results from the potassium salts); but he gave only small doses (3 to 5 gr.), and his results need confirmation. Bartholow found that assimilation was *retarded* by the continued use of bromides, and he traced emaciation to this cause. I have sometimes noted emaciation from these medicines; but it is by no means invariable, as shown in ten patients at Hayward's Heath Asylum, who took daily doses of less than 1 dr. of the potassium salt. Ordinary secretion and excretion were not affected, but all these patients increased in weight, and in another series of patients who took more than 1-dr. doses, some lost weight and some did not (Dr. Williams). The increase of weight would accord with the conclusions of Bill and Rabuteau, but minute analyses were not made.

Cutaneous System. — Perspiration is diminished under bromide of potassium. Various kinds of *eruption*, erythematous or acneiform in character, are commonly traced to this drug, and although several observers maintain that they are wholly due to some contained *iodide*, they seem in greater or less degree inseparable from bromide medication, and occur with almost equal frequency after the ammonium, sodium, or other compounds.

They affect mostly the face, the arms, the back, and the buttocks, but may be general. They present papules, vesicles containing sebaceous matter (seborrhœa—Fox), or pustules, and even crusted tubercles of carbuncular character, and have been termed "confluent acne" (Cholmeley) and "molluscoid acne" (Neumann). Voisin distinguishes five different kinds of "bromide rash" (Archives Gén., 1866–67). Usually there is a hard, red swelling, with a small point of suppuration in the centre: this may be quite small—a mere papule—or of large size. An eruption of this kind has occurred in a

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child at the breast, whose mother was taking the medicine and was not herself affected (Lancet, ii., 1874, p. 657). A more rare, but still recognized form, is that of erythematous patches, which may be local or general (Veiel, Med. Times, ii., 1874, p. 152; i., 1878, p. 151).

SYNERGISTS.—The sedative action of the alkaline bromides on the nervous system is assisted or modified favourably under certain conditions by chloral, cannabis, and opium; their regulating effect upon vaso-motor nerves especially by quinine; their depressant effect upon the circulation is aided by aconite, gelseminum, veratrum viride, and digitalis, also by nitrate of potash and allied salts; their alterative power is increased by cod-liver oil, iodides, and alkalies, though iodides would interfere with sedative action.

ANTAGONISTS. — True stimulants, such as alcohol, ether, and coffee, which tend to induce arterial congestions, oppose the action of bromides; thebaine and narcotine, strychnia and nicotine, are also antidotal. Strychnia especially has an opposite effect on the cord and the medulla oblongata, though without a direct action on the brain or the muscles. The difference in the capillaries of the spinal centres post-mortem, after using the two drugs, was especially noted by Saison; under bromide the vessels were scarcely visible, under strychnia intensely congested.

Atropia antagonizes in some degree bromal hydrate (Hughes Bennet, B. M. J., i., 1875), and ergot is opposed, in its full action, to bromides—although any of the above-named drugs may at times be usefully combined with them, and made to modify their ordinary action for certain therapeutical results. This is evidenced by clinical experience.

Dr. Bill argues that chloride of sodium is antagonistic to bromide of potassium, and that the latter remains longer in the system if the former salt be avoided (Amer. Journ., 1868).

The value of arsenic in curing and preventing bromide rash has been asserted by several observers, and lately Dr. Gowers has published illustrative cases (Lancet, i., 1878).

THERAPEUTICAL ACTION. — *External.* — Morbid Growths, etc.—Bromide of potassium, applied in fine powder

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to indolent ulcerations and morbid growths with raw surface, is said to act well and painlessly as an alterative or caustic. An epithelioma has been successfully treated in this manner (Perrant, Med. Times, ii., 1876, p. 368).

Mixed with simple ointment (1 part in 5), or with glycerine, it forms a sedative, somewhat astringent application for painful and sloughing ulcers, also for painful conditions of mucous membrane, hæmorrhoids, and anal fissure, and for chronic eczema and acne.

A lotion containing 1 part to 50 of water is said to restrain hæmorrhage (Lancet, ii., 1876, p. 474).

THERAPEUTICAL ACTION.—*Internal.*—In 1826, Barthez, Andral, and some few other (French) observers, ascertained that the bromide of potassium could relieve arthritic pain, and Pourché found it useful in bronchocele. Dr. Robert Williams (of St. Thomas's Hospital) reported such success with it in the treatment of enlarged spleen, as to contribute to its introduction into the London Pharmacopœia of 1835, and yet it is instructive to remark, that so little clinical evidence of its value was obtained by others, that the medicine was omitted in that of 1851. Puche, however, found it to cause partial anæsthesia; and Thielman, a Russian physician, noted its sedative influence on the generative system; and from these suggestions Sir Charles Locock was led to use it in epileptic or epileptiform attacks, connected especially with ovarian or uterine excitement, and the mention of his successful results at the Medico-Chirurgical Society, in 1857, was practically the commencement of general knowledge on the subject.

Epilepsy.—For this malady the bromides are now, by common consent, held to be the most generally reliable remedies. They give the best results in *sthenic* cases of uncertain causation, when convulsive attacks are very violent but have not become chronic. Attacks connected with tumour, or injury, or organic lesion, are also more or less relieved, probably in proportion to the amount of *hyperæmia* present. Dr. Wilks found better results from bromides in *traumatic* cases than in any other (Med. Times, ii., 1861, p. 635), and Dr. Broadbent noticed the same fact (Lancet, i., 1866, p. 92). Where there is *excentric* irritation, as in the

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generative system or the abdominal organs, benefit is almost always obtained, and Dr. Bill has compared the action of bromides in such cases to that of a ligature, interrupting communication between an impression or "aura," and the brain; they seem to diminish not only conductive, but reflex function. In a case in my own practice, where a large uterine fibroid produced alarming epileptiform symptoms, opium invariably increased the spasms, but bromides relieved quickly.

Minor forms of epilepsy, as "petit mal," evidenced by transient vertigo or loss of consciousness, with perhaps some spasm, but not true convulsion, are not so certainly relieved; and when the epileptic attacks occur only, or chiefly, at *night*, and at *long intervals*, bromides are not always the best remedies; also in very chronic cases of many years' duration, they can usually do little more than modify the character of the attacks. When the patient has become nerveless and stupid, belladonna has the advantage over bromides, and when there is marked anæmia or profound depression, they are not desirable. Nux vomica, or strychnia in small doses, will act better, especially if consciousness be not completely lost during the fits. It must be noted, however, that according to statistics recently published by Dr. A. Hughes Bennett, all varieties of the disorder—petit mal, nocturnal or chronic epilepsy—have shown good results in large proportion under bromide treatment (Edin. Med. Journ., Feb. 7, 1881).

Supposing the case be one suitable for this, it is important for success that it should be carried out thoroughly, in sufficient doses, and continued sufficiently long. It must not be interrupted as useless in any case, unless distinct evidence of its physiological effect has been obtained without relief to the symptoms. The production of drowsiness, or of a characteristic skin-eruption, may be taken as some guide, but a better one will be found in the degree of insensibility produced in the fauces; if no irritation or retching is caused by touching the uvula or pharynx, then probably the patient is under bromic influence. From 10 to 40 gr. thrice daily is an average limit, more being given at night-time if necessary. At first, even larger quantities may be required, and many instances of success from very large doses are on record. Puche and other French physicians have given

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100 and 200 gr., but not without some vomiting and prostration (Med. Times, i., 1874). Dr. Squibb found 60 gr. act well when less failed, and he notes that if the medicine needs to be omitted for a time, it should be resumed at the full dose again. Dr. Farquharson gave 30 gr. four times daily with benefit, to a child, aged five; and Dr. F. Beach, at the Clapton Asylum, commonly gives 15 gr. every two hours for a time, and 1 or 2 dr. during a paroxysm (B. M. J., ii., 1877). Thirty grains thrice daily have been taken for twelve years, and although before treatment the patient was incapable of work, he became equal to the conduct of an ordinary business (*ibid.*, p. 655). There was no effect on the sexual power. I have often myself given similar large doses, and for a long period, but there is no *one* rule to follow, as I have found 10 gr. act as effectively in some cases as 60 gr. in others. Sometimes 5 gr. will cause troublesome acne.

When the attacks are once controlled, a single daily dose of from 20 to 60 gr. will usually suffice to keep up the effect, and may have to be continued for many months or years. Bromide, indeed, has been well called the "food of the epileptic," and sometimes needs to be taken as regularly as food; still, an occasional intermission—one or two days in a week or fortnight—is usually desirable, for thus the effect of the medicine is better preserved with less injury to the patient. It is necessary to watch carefully its effect on the general health, and to omit it, or at least to lessen the dose, if the skin should be much affected, the extremities become cold, or anæmia, prostration, or diminished sexual power be traced to it. In exceptional cases there has been developed, under bromides, a peculiar general irritability of asthenic character, or even an excited condition resembling mania (Sequin, Voisin). Minor symptoms, such as headache, "stuffiness" of head, lachrymation, and gastric irritation, have been connected with the use of a preparation adulterated with *iodide* (Legrand du Saulle, Med. Times, i., 1872, p. 319). If during the omission of treatment convulsion threatens to return, bromide should be at once resumed, but perhaps in a different combination.

For weakness or anæmia, quinine or iron may be added with advantage. Strong coffee hinders development of bromism

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(Echeverria), and arsenic in small doses will prevent or cure bromic acne. The addition of a small quantity of strychnia to the bromide is recommended by Brown-Séquard and by Tyrrell (Med. Times, i., 1871, p. 36); it certainly should be only in small doses, or it would antagonize the bromide. Nux vomica, in my opinion, holds but a doubtful place in the treatment of epilepsy; it will improve digestion, and give "tone" to a relaxed nerve-system, and relieve convulsive attacks when consciousness is not wholly lost, but in such cases it acts better alone than with bromide.

Several alkaline bromides taken together sometimes act better than any single one (Brown-Séquard), and I have often found advantage from combining the potassium and ammonium salt. General experience has not yet corroborated the observations of Weir Mitchell as to the superior efficacy of the lithium salt, nor of Hammond as to the bromide of calcium, but they may be useful as alternatives. The bromide of sodium is less depressing to the heart than that of potassium, as has been illustrated by Dr. Hollis (Practitioner, 1878).

I cannot speak well of the addition of belladonna, often recommended. That medicine has its own field in cases rather acute in character, difficult to diagnose, but on the borderland between epilepsy and eclampsia. It is especially useful when they are traced to sudden fright, and are attended with congestive headache between the attacks, and again in the eclampsia of robust plethoric children with cerebral congestion; but, when given in combination with bromides, I have found its action unreliable and confusing. Dr. Beaman combined lactucarium and lupuline (Lancet, ii., 1867), and the addition of digitalis has been found valuable (Lancet, ii., 1871, p. 705). I have myself seen excellent results from the last-mentioned in conjunction with bromides, in epilepsy connected with masturbation or nocturnal emissions; it has marked control over such conditions.

I find it best to give the digitalis separately, morning and afternoon, and the bromide at night, and have found this treatment stop the onanism and emissions, and cure the epilepsy. The infusion of digitalis is the best preparation, and should be given in ½ to 1-dr. doses.

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Charcot recommends the bromide of zinc (B. M. J., ii., 1877, p. 132), and Bourneville the bromide of camphor (i., 1877). I have frequently tried the latter compound, but have never seen from it results which could not be better obtained from other bromides, or from camphor separately. Beigel recorded good results from bromide with morphia hypodermically (Med. Times, i., 1869, p. 68), but morphia, when given internally for any length of time, acts injuriously, and when subcutaneously administered for a similar time is still more detrimental.

I am satisfied, from careful and long-continued observation, that opium does not, in any form or combination, cure epilepsy, but when convulsive attacks occur as complications of passing mental disease, it is sometimes helpful, either alone or combined with bromides, for allaying excitement and convulsion for a time, and procuring sleep, but its effects are transient.

The proportion of *cures* obtained by bromides or their combinations—meaning a cessation of convulsive attacks for from six months to four years or upwards, according to the period that cases remained under observation—has been stated at about *one half* for adults, and one quarter for children (Voisin, Legrand du Saulle), and even if *absolute* cure be not obtained quite in such proportion, it is so sufficiently often to prove its possibility. Probably, however, in the majority of cases, freedom from attack will be contingent upon more or less continued use of the remedy. In cases that are satisfactory, we see nothing of an effect sometimes mentioned as an objection to the use of bromides, viz., a greater violence of the attacks as they become less frequent. It is true that this occurs sometimes during the natural course of the malady, but it cannot be directly connected with the medicine; on the contrary, this, as a rule, diminishes the severity as well as the frequency of the convulsion.

Binz has suggested that not only the physiological, but also the therapeutical, effect of the bromide of potassium is due to the latter agent (potassium) improving the blood-condition, etc. (Practitioner, 1874), and Sanders even states that the *chloride* of potassium has answered equally well in his hands (Centralblatt f. Med., 1868); but whilst we agree that some of the depressant effects of bromide of potassium in the circulation might be explained by the known action of potash, its effects on the nervous system

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cannot be so, and the result of Sequin's observations showed tha the use of chloride of potassium *increased* the attacks in case which bromide *relieved* in the proportion of 80 per cent. (Med Times, i., 1878). The nitrate and bicarbonate of potash hav also been proved useless (Anstie, Practitioner, 1874).

In the Gulstonian Lectures for 1880, Dr. Gowers, statin the results of his experience in the treatment of epilepsy, say that when small doses of the bromide are given to ward of regularly recurring attacks, they should be taken only a shor time—two or three hours—before the fits are expected; that they will fail if taken at longer intervals before. Larger doses may, however, be taken then. He has met with many cases in which he has noticed a cumulative effect of the drug, but many others in which, after a time, a tolerance of it, or indifference to it, is attained, and an increase of the dose becomes necessary to obtain the customary result. To *control* the fits the bromide must be given frequently, but not in larger doses than a drachm or a drachm and a half in the day; but for the *cure* of the disease he considers it necessary to keep the patient for a time under the full influence of the drug, by giving a large dose every two or three days—as much as can be well borne. Gowers has given, in this way, as much as an ounce at a time, but adds the caution not to begin with a larger dose than half that quantity. He considers that only in this way can the "stability of the resistance of the nerve-cells" be re-established. The drugs that he has found most useful in combination with bromide where that, by itself, has failed, are digitalis (where there is associated cardiac disturbance, or in nocturnal epilepsy), belladonna, cannabis indica (when between the attacks there is persistent headache), and iron.

Convulsion.—In the wide range of convulsive and spasmodic disorders, *outside* that which we distinguish as epilepsy, bromides are very efficacious. In the convulsions occurring during *pregnancy* especially from reflex irritation at the time of parturition, they are more distinctly indicated than in the albuminuric form, but I have seen them also relieve the latter. Peaslee thought them valuable only during the threatening stage when the urine is scanty, and certainly, the earlier the patients are brought under their influence, the more satisfactory the result. In *Uræmic Convulsion* some observers

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have objected to the use of bromides, but they have been found generally of some assistance in lessening the paroxysm; eliminant and other remedies should be conjoined. The dose in such cases should be large, ½ dr. every hour or two. When swallowing is impossible, they act well given in enemata (Gimbert and others, Med. Times, i., 1872, and i., 1874).

Dentition. — In the restlessness and nerve-irritation or convulsion sometimes attendant on dentition, bromides are exceedingly useful, "so that the gum-lancet is scarcely ever needed." The convulsions even of meningitis I have frequently seen arrested by the bromides.

Tetanus—Strychnia-poisoning.—We have shown reason to believe that bromides lessen spinal congestion, and diminish reflex irritability (*v.* p. 129); and this being so, they ought to prove valuable remedies in the disorders named. We have not a large amount of clinical experience on this point. In a recent collection of 415 cases of tetanus by Dr. Yandell, bromide does not seem to have been used once (Brain, Oct., 1878), but Dr. H. C. Wood has tabulated 18 cases of tetanus thus treated, and of these only 2 died; in 1 of them, large doses of belladonna confused the result. In most of the successful cases, chloral or morphia was given at bedtime.

Dr. Southey relates a successful case, in which conium was combined (Lancet, i., 1875). Of the bromides, full doses—at least ½ oz. in the twenty-four hours—should be given.

Saison found with animals, that hypodermic injections of strychnia distinctly modified the action of bromide, and *vice versâ*; and there are a few instances in which a fatal result from poisoning was, in all probability, prevented by bromide treatment. Thus, Dr. Gillespie records a case in which nearly 3 gr. of the alkaloid were taken, and very serious symptoms developed; but recovery took place under the influence of an ounce of bromide given in divided doses—no vomiting occurred (Amer. Journ., Oct., 1870). In Dr. Hewlet's case, more than 4 gr. of strychnia were taken, and although vomiting had occurred and opium been given, severe convulsions had set in; 90 gr. of bromide were administered, at first every half-hour, and afterwards, 60 gr. every hour, and twenty-six hours after

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the first dose the patient could walk (Brit. and For. Rev., July, 1871). Another case of recovery after a 3-gr. dose of the poison, and similar treatment, is given by Dr. Bard (Philad. Med. Times, June, 1871—Record, 1879).

Migraine, Congestive Headache, etc.—If given in the prodromal stage of an attack of migraine, the bromides often succeed in preventing its development, and especially when the head-pain and the nerve-disturbance *precede*, or are more prominent than the nausea or gastric disorder (Yandell, Latham). Five grains every hour or half-hour may be given, but if an attack *has already set in*, a full doze of 20 to 30 gr. is better, and if this produces sleep, the patient usually wakes free from headache. After the paroxysm has *fully* set in, the remedy does not seem to control it (Med. Times, i., 1875, p. 338).

In ordinary congestive headache, with flushed face, and intolerance of light and noise, and in congestive neuralgia generally, the bromides are serviceable; also in the headache occurring in delicate children from even moderate application to study. Dr. Day recommends their use with iodides for children who suffer from constant headache and debility (Lancet, i., 1875, p. 854); but I have been disappointed with this combination under such circumstances.

Chorea.—The varying results obtained in the treatment of chorea must be connected with its varying pathology, which is not yet well understood. I have seen a few patients recover rapidly under treatment by bromide, but the majority are too anæmic or asthenic to bear it well; hence it is not surprising that Dr. R. Reynolds found it even prejudicial in some cases.

Dr. Ramskill tried fully the potassium salt, "and with strong prejudice in its favour," but without satisfactory result. Camphor bromide is said to have acted better (B. M. J., i., 1877), but has not done so in my experience.

Hysteria.—In ordinary cases of hysteria, bromides alone do not give the relief that might be expected. The convulsive epileptiform seizures which sometimes occur may be controlled by them when the patients are fairly strong, but mere emotional disturbance and nerve-debility are better treated by other remedies. The malady is essentially connected with enfeebled nerve-power. Gubler indeed compares its paroxysms

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to convulsions after hæmorrhage, and in such cases bromides are not really curative. In *combination*, *e.g.*, with iron, valerian, or camphor, they may be of more service.

Uterine Irritation.—If hysterical symptoms be definitely connected with ovarian irritation or uterine congestion, then the bromides are more distinctly indicated. In the distressing condition of unrest, undue apprehension and depression, which often occurs at the climacteric period, they may prove of the greatest service, quieting the restlessness, and relieving the sense of fulness in the head, and flushing of the face. Dr. Ringer found them to exert a favourable influence over the apprehensive and desponding thoughts which arise sometimes in the later periods of pregnancy (Lancet, i., 1869), and they have relieved even the sensations and symptoms of a "spurious pregnancy," occurring at the climacteric period (Simpson, Med. Times, ii., 1859).

Spasmodic Disorders — Laryngismus. — The bromides, but especially the bromide of ammonium, will be found very useful in relieving the laryngeal spasm of this disease; but its usual connection with rachitis must not be overlooked, and tonic treatment, good hygiene, and improved nutrition must be combined for a satisfactory result.

Pertussis.—Dr. Gibb was one of the first to ascertain the value of bromides in this disorder, and he found the ammonium salt to act best; it quickly relieved the whoop, *i.e.*, the laryngeal spasm. Dr. G. Harley also early recorded satisfactory cases (Lancet, i. and ii., 1863). I have often verified this use of the bromides, especially in early stages. I order for children 3 to 5 gr. every two to four hours, as a rule not giving more than 20 gr. in the day, because of the depression induced in weakly subjects: I often combine belladonna, and sometimes chloral, with the treatment. Dr. Ringer reports them as useful only in simple uncomplicated cases, but neither dentition nor a pyrexial state need prevent their use if the spasm continue; they are fairly presumed to lessen congestion in the medulla as well as in the mucous membrane of the fauces, and to diminish reflex excitability.

If catarrh be present, an expectorant may be conjoined, and if bronchitis or pneumonia supervene, the spasm generally sub-

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sides for a time, and a different treatment is indicated. The convulsion of pertussis I have frequently seen relieved by bromide, but belladonna is much more serviceable.

Dysphagia.—There is a peculiar form of difficulty in swallowing liquids which I have seen only in children; they drink readily, but the fluid either returns at once from the mouth or partly chokes them, or they remain, with open mouth, gradually swallowing small quantities with continued muscular spasm. No definite cause can be assigned. The symptoms come on a few months after birth, and I have seen it mostly amongst the children of the poor. It may be relieved by bromide, and Dr. Ringer has remarked that a similar condition, when congenital, is much benefited by bromide of potassium.

The dysphagia of phthisis, connected with local irritation and inflammation, is also relieved by the salt, which should be swallowed slowly and well diluted with mucilage.

Colic.—In cases of cramping pain in the stomach or intestine, such as occurs more frequently in children, and is independent of diarrhœa, but connected with irregular muscular contraction, the bromides usually relieve better than other remedies.

Spasm of Rectum and Bladder.—In cases of tenesmus, whether of the bladder or rectum, bromides will often be found useful. Hammond recommends bromide of camphor (B. M. J., i., 1877), and ½-dr. doses of bromide of potassium have given relief to a severe case of rectal spasm when opium, belladonna, and instrumental interference all had failed (Lancet, ii., 1873, p. 456).

Enuresis.—In the simple enuresis of children bromides may usually be relied upon. The good derived from them is probably due to "increasing the stability of resistance of the cells in the lower part of the spinal cord" (Gowers).

Spasmodic Asthma.—There are certain cases in which very striking results may be obtained from the bromides: *e.g.*, a man, aged thirty, subject to attacks since infancy, suffered about once in the week from evening till two or three o'clock the following morning, but after a fortnight's treatment with full doses of bromide taken at night, he had no further attacks (Saison). As a

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rule, it will be found that this remedy does not act so well as an "antispasmodic" *during* the *paroxysm*, but better if given during the *interval*, apparently by exerting a sedative influence on the central nervous system.

Dr. Begbie found it very successful in two cases (Edin. Med. Journ., 1866), and G. Sée reported that though the catarrhal element in the malady was not modified, the access of paroxysms was delayed, and the dyspnœa lessened or quite controlled (Bulletin, 1865). I can recommend the bromide in chronic cases of asthma, and especially when there is excentric irritation, as of the pelvic organs; it is sometimes well combined with iodide.

Angina Pectoris—Palpitation.—The bromide is sometimes of service in severe breast-pang. Thus, Papillaud relieved severe paroxysmal attacks by the use of ½ to 2-dr. doses continued "at intervals" for two or three months. In nervous palpitation it is often a very good remedy, and I have known it especially relieve gouty patients. Berger found bromide of camphor to answer well.

Vagus Irritation.—Dr. Somerville has related a remarkable case in which a very slow pulse of fifteen to twenty per minute was found on one occasion after an error in diet, and seemed, therefore, connected with irritation of the gastric terminals of the vagus; the slowing was succeeded by quick tumultuous heart-action, and during this stage marked benefit was derived from bromide (Practitioner, March, 1876). It was, however, given with belladonna.

Undue Reflex Action, Vomiting, etc.—In a number of cases, somewhat dissimilar in symptoms, but connected with exaggerated reflex action, whether spasmodic in character or exhibiting altered function or secretion, the bromides prove useful. In reflex vomiting, as that of pregnancy, or even in sea-sickness, and sometimes in cerebral vomiting, they give relief. Five to ten-grain doses, if retained, are often sufficient, but in obstinate cases connected with pregnancy, ½ to 2-dr. doses have been successfully given by injection (Lancet, i., 1874, p. 770). Laborde has seen it useful in the vomiting of various gastro-intestinal disorders.

Diarrhœa.—When this is reflex in character, as it often is

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during dentition, or when associated with a congested relaxed state of intestinal mucous membrane, bromides may prove the best remedies.

Cholera.—It is not going beyond our knowledge to state that capillary spasm and congestion of vaso-motor centres are essential elements in the phenomena of cholera, and it would not, *à priori*, seem unreasonable to expect benefit from bromides; there is certainly some clinical evidence of it. Thus, Dr. James Begbie, giving ½-dr. doses of the potassium salt, noticed that capillary circulation was quickly re-established, as shown by the return of colour to the limbs, and the recurrence of urinary secretion that had ceased: he considered the remedy a valuable one (Edin. Med. Journ., and Lancet, ii., 1866). Dr. Henry Sutton has also published cases of recovery under its use (Med. Times, ii., 1867).

Menorrhagia—Leucorrhœa.—Bromides often act very well in relieving both of these discharges, but especially the former when dependent on congestion.

Spermatorrhœa, etc.—In irritation of the male genitals in plethoric subjects, with undue erections or excessive seminal losses, the bromides are often highly useful. They have a local anæsthetic effect when applied to the urethra, and when taken internally their value is evident rather in cases when sexual excitement is connected with local irritation and congestion, as hæmorrhoids, ascarides, etc., than when there is mental or central causation. They tend to lessen, also, spinal congestion and reflex irritation. Berger finds, perhaps, the best results from camphor bromide in such cases (Med. Times, i., 1877, p. 264). When there is marked debility with anæmia, or when spermatorrhœa is unaccompanied by erections or sensations, bromides are not the best remedies.

Cystitis—Urethritis.—Saison has seen the bromides give great relief in these cases. They should be used both locally and internally.

Disorders of Sympathetic Nerve.—A number of anomalous symptoms which may be referred to this cause are relieved by bromides; for instance, "sudden numbness, coldness, deadness, or pricking sensations in one or more limbs; distressing, indefinable feelings in the epigastrium or abdomen; or sensa-

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tions akin to rigor, with much anxiety and palpitation or 'fluttering' of the heart." In such cases the local circulation may be interfered with, the pulse in one arm becoming irregular and faltering, whilst in the other it may remain unaltered, and the heart-beats continue normal.

Urticaria.—In the capillary congestion of this malady, which is connected with irregular action or paresis of vaso-motor nerves, the bromides are indicated. Thus, Dr. Andrews reports the cure of a chronic recurrent case under their use (Lancet, i., 1870, p. 402).

Exophthalmic Goitre.—According to Dr. Brown (U.S.) and others, the bromides have proved useful in this malady, (Brit. and For. Rev., i., 1868), and I think benefit may usually be expected from them, especially when combined with quinine.

Phthisis Pulmonalis.—There are certain distressing phthisical symptoms which are amenable to the influence of bromides on vaso-motor nerves and reflex action. Thus, a hacking laryngeal cough, or reflex vomiting, or even pyrexia, may be relieved; also the difficulty and pain in deglutition connected with pharyngeal irritation. Profuse sweating and even flux from the bowels may be controlled by the bromides—especially by bromide of calcium—though usually the anæmic and depressed condition may be met better by acids or mineral astringents.

Insomnia is but a symptom, and one produced by various and often opposite pathological conditions. We accordingly find that the different hypnotics cannot be used with equal success in all cases presenting this one symptom in common, and so while bromides are of most signal value in some conditions, they are useless or even harmful in others. This may be explained partly by varying conditions of the blood-supply, partly by difference in the states of nutrition of the nerve-cells. It is when there is *moderate cerebral hyperæmia*, such as probably exists after prolonged mental effort—whether associated with study, with excitement, or anxiety—and when unrest and sleeplessness are marked symptoms, that the bromides are far more soothing, and more curative, than opium, and even if inflammatory action be present they may still be very serviceable, in conjunction with aconite, ice, or other remedies.

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If there be much cerebral *anæmia* it may be even increased by the remedy, and I have seen, in debilitated hypochondriacs, and in some aged people, aggravation of the symptoms with marked increase of the prostration. In some cases of senile insomnia, I have, however, found it very useful given with the last meal, in doses of 10 to 20 gr. or more dissolved in milk, tea, soup, beer, or cold water. In the sleeplessness of convalescence from acute disease and of dyspepsia, bromide is useful, combined in the latter case with dietetic and other special treatment. In pregnancy, where pain is suffered and prevents sleep, a combination of chloral and bromide—15 gr. of each—is especially useful. In weakly subjects, and especially in the insane or hypochondriacal, bromide is best given in combination with cannabis indica. When insomnia is induced by severe pain, opium is the best remedy; but its effect is heightened, and its tendency to produce headache, faintness, or nausea lessened by bromide. Da Costa recommends the latter to be given in full doses half an hour before, and two hours after, the opium.

To choose a suitable quantity is of importance; it is usually from 20 to 30 gr.

Wolfe relates a case of insomnia with hypochondriasis and irritability from over-anxiety, when 5 gr. proved useless, but ½ dr. "acted liked a charm." Behrend relates two very good illustrations of nervous excitement and anxiety, with loss of sleep, in which 25 gr., at first thrice daily, afterwards less often, proved quickly curative (Lancet, i., 1866; ii., 1864, p. 1). In the sleeplessness and delirium of fevers, the bromides exert a favourable influence in procuring sleep, and they prove a valuable resource when opium is not admissible.

I have sometimes found bromide of camphor, in 3 to 5-gr. doses, procure sleep for hysterical subjects, and Deboul recommends it in the unrest of cardiac disease, and of phthisis (Brit. and For. Rev., i., 1865). The solid capsule of Clin is liable to cause gastric irritation, and is better given dissolved in milk.

Delirium Tremens.—For the excitement, wakefulness, fright, and tremor which follow the abuse of alcohol, and which commonly precede a fully-developed attack of delirium, large doses of bromide often prove of great use, either with or without opium. I have known them prevent the further

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development of the attack; in later stages they have not the same power, but bromides have acted well combined with chloral. To this statement I must, however, add a caution as to the use of full doses of the latter remedy in delirium tremens, for I am cognizant of more than one case of sudden death traceable to it, in all probability.

Gubler has written specially on the value of bromides in amblyopia and alcoholic amaurosis.

Night-terrors — "Nightmare."—Children especially are liable to attacks of terror in the night, when they awake screaming, and are so deeply impressed by some imagination or dream, that they are, at first, scarcely conscious. This condition is connected with a reflex irritation of the nervous system, and is much under the control of a night-dose of bromide. The nightmare of adults may also be relieved by it; aperients should not be neglected in such cases.

Mania.—The use of the bromides in insane patients requires special study and care, because of their liability to be suddenly depressed, and the prostration I have sometimes seen well illustrates the clinical fact, that an enfeebled, ill-nourished nervous system often contra-indicates these medicines, even if the general bodily health seems to be fair.

Dr. S. W. D. Williams records that of thirty-seven insane epileptics treated by bromides, the fits were relieved in most, but great depression occurred in some of them without any relief to their attacks; ½-dr. doses proved too large; catharsis was caused in two cases, and possibly the rapid development of phthisis in a third (Med. Times, ii., 1864, p. 88).

Mr. Wood (Durham) has also recorded instances amongst insane patients of "sudden development of severe prostration and despondency" (B. M. J., ii., 1871), vomiting and abdominal pain were also caused.

Dr. Clouston, in a careful study of the effects of different medicines upon the nerve-condition of lunatics, found that the bromides, if given alone, needed to be used in very large doses for the subduing of violent paroxysms. One female patient took 7 oz. in divided doses, but then suddenly lapsed into a condition of extreme "torpid depression," not free from danger to life, and continuing many days. The same physician ascer-

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tained that a combination with cannabis indica gave, even in small doses, much better results than either remedy alone, ½ dr. of each given together acting as a hypnotic better than 1 dr. of tincture of cannabis indica, or 2 dr. of bromide (Med.-Chir. Rev., ii., 1870, and 1871).

Puerperal Mania.—In acute stages of excitement and delirium connected with the puerperal state, bromides act well and should always be given. They have, doubtless, an influence over the uterine and ovarian congestion of that state, and over reflex irritability, and many successful cases of use are on record. Curgenven has found the potassium salt act quickly and well when given by the rectum. I have often given it alternately with aconite, with much advantage.

Erotomania — Nymphomania. — When these conditions occur in connection with a generally demented state, the bromides do not seem to relieve so much as might have been expected. My friend, Dr. Mackey, when in charge of a large asylum at the time when bromides were first introduced, and were specially recommended in sexual cases, gave the potassium salt to many of the younger patients, especially youths addicted to masturbation, but generally with the result of inducing extreme and miserable depression, without controlling the symptom. Dr. Williams also noted that in his thirty-seven insane cases the sexual system was not at all, or but slightly affected. Even in subjects of average mental health, but addicted to onanism, the bromides, though they lessened the venereal appetite for a time, effected no cure in Dr. Bill's experience, and he concluded that they could lessen only *excentric* sexual irritation (Amer. Journ., July, 1868). In this they certainly are highly valuable. In the few cases that I have seen approaching to nymphomania, benefit was derived from the bromides alone, but they act best when given in conjunction with baths, counter-irritation, and moral agencies. Dr. E. C. Clarke and Dr. Begbie have recorded very satisfactory results.

Cerebral Apoplexy.—There is reason to hope for advantage from the use of bromides in the symptoms of cerebral congestion which point to an apoplectic tendency. Dr. Bastian has remarked, that in such cases, when the heart-action is forcible and frequent, these remedies, conjoined with aconite, are

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very suitable, and I quite concur in this statement (Lancet, ii., 1874, p. 897).

Meningitis—Hydrocephalus.—I have seen the convulsions of traumatic meningitis arrested under bromide of potassium, and it is said that recovery from tubercular meningitis (acute hydrocephalus) has followed its use. In support of this statement Dr. John Brunton has recorded four cases (Glasgow Med. Journ., 1873), in which the heads were enlarged, and the symptoms were certainly serious, but there were no convulsions, and the diagnosis must be held rather doubtful (*cf.* pp. 112, 113).

Spinal Congestion — Cerebro-spinal Meningitis. — In spinal congestion of acute character, with pain, hyperæsthesia, cramp, and spasm, the bromides have proved so far useful as to merit always a fair trial.

In true cerebro-spinal meningitis—though a very fatal disease under any treatment — I have seen great advantage from bromides, but like all depressant remedies they must be used with caution, for there is liability to sudden failure of the circulation from conditions of the disease itself. Subject to the same caution, I think it desirable to conjoin aconite or belladonna throughout the treatment.

Diphtheria.—The bromides have proved valuable in this disorder, both when taken internally and when applied to the inflamed parts. Dr. Caro uses a spray containing 1 dr. to the ounce, and finds it lessen capillary congestion, and when the cough is dry it aids the expectoration of membrane (Med. Times, i., 1874, and i., 1876, p. 588). Dr. Post recommends a solution of the same strength with 20 min. of bromine, and gives 10 drops every hour to a child of three years.

Rheumatism.—The bromide of ammonium has been found extremely useful in acute rheumatism by Da Costa (Amer. Journ., April, 1871). Guéneau de Mussy also praises the bromide for the same malady. For subacute cases, for rheumatic gout, and for the resulting stiffness and nodosity of joints, the bromide of lithium is recommended (Bartholow). This remedy is certainly valuable for relieving the wakefulness and delirium of rheumatic fever; morphia may occasionally be well combined with it.

Bronchocele—Splenic and Glandular Enlargements.—

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The great value of bromides in nerve-disorder has led us, perhaps, to think less of them as remedies in scrofulosis and glandular enlargements, but they are often very useful in such conditions. Dr. Wilks recorded their good effect in bronchocele (Med. Times, ii., 1861, p. 635), and I have used them frequently and successfully in gland-swellings connected with struma. They have been by others recommended in combination with liquor potassæ (Lancet, i., 1860, p. 62). The bromo-iodine waters of Kreuznach and Woodhall Spa are also good forms for their administration.

Dr. Robert Williams found the bromide of potassium extremely useful in reducing enlargement of the spleen (malarial), and, in an appendix to his classic work on Morbid Poisons, gives several striking instances of its value when other and better-known medicines had failed.

Mr. Spencer Wells has confirmed the observations of Dr. Williams, and, amongst other cases, has recorded that of a child, aged eight, extremely emaciated, suffering from hectic, and with the abdomen distended by an enormously large spleen, the lower edge of which extended to the pubes. The case seemed apparently beyond the power of medicine, but yet, under the influence of 3 gr. of bromide thrice daily, some diminution was produced within a week; under 5 gr. this continued, until at the end of a few weeks the viscus was above the umbilicus, and the child convalescent. The case was either connected with ague or with blood-poisoning from unhealthy atmosphere, and is a very remarkable one. Acting on the suggestion of Mr. Spencer Wells, I have myself used the drug in similar cases, but in larger doses, and have been pleased with it. Claude Bernard has recorded equally good results, but with doses of 20 to 40 gr. daily (Bulletin, 1874).

Enlarged Tonsils.—Saison has seen the bromides of service in this condition, and in the recurrent angina connected with it.

Fibroid Tumours.—The power which bromides possess of stimulating absorption led to their use in cases of uterine fibroid, and Simpson recorded successful results (Med. Times, ii., 1859, p. 599), also Graily Hewitt (Med. Times, i., 1861).

The Kreuznach waters, which contain bromides and iodides, have long enjoyed a special reputation in such cases; but, if we

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are to judge by a discussion of some years ago, many eminent authorities in London have seen little or no advantage from them (Med. Times, i., 1857). My own experience, however, and personal observations made at Kreuznach, have satisfied me that a course of these waters *does* often diminish the congestion and the fibroid growths, although their good effects probably are not *wholly* due to their containing bromides and iodides. In many of my cases the waters have also removed or reduced dense infiltrated deposits around the growths, and have given much relief and comfort to the patient (*v.* p. 214.)

Ovarian Tumour.—The Kreuznach waters acted so favourably upon several of my patients with unilocular ovarian cysts, that I now always recommend one or two courses of them before advising an operation. Bromides given in 5 to 20-gr. doses two or three times daily, and continued for months, frequently diminish the size of the cyst, and improve the general health. The dose should be varied from time to time, according to circumstances.

ABSORPTIVE EFFECTS OF BROMIDES.—There are other growths and deposits in which these effects have been utilized by different observers, but not extensively. Dr. Wilks observed benefit from the bromide of potassium in cases of cephalalgia dependent on thickened membrane or thickened bone (Lancet, i., 1870, p. 191); Dr. Brown, in acute and chronic inflammation of testes and chronic inflammatory enlargements (Brit. and For. Rev., i., 1868); and Dr. Bird states that from ample experience in Australia, where hydatids are common, the continued administration of bromides has the power of destroying the parasites, and causing absorption of the cysts (Med. Times, ii., 1873, p. 164). (For a similar effect of iodide, *v.* p. 112.)

PREPARATIONS AND DOSE.—*Potassii bromidum:* dose, 5 to 20 gr. and upwards (*v.* pp. 136, 137, 140). *Ammonii bromidum:* dose, 2 to 20 gr. and upwards.

Concerning the different bromides, we may here briefly state that the *potassium salt* is in the most common use, but contains the least bromide of the alkaline salts (*v.* pp. 125, 126), and is more depressing to the circulation.

The *sodium salt* I consider rather more powerful as a bromide,

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though all observers are not agreed on this point. It is less depressing, and is more easily assimilated (Clymer, Med. Times, i., 1872, p. 238).

The *ammonium salt* possesses some of the stimulant characters of its base, which is liberated by decomposition. Its action is said to be more rapid, but also more evanescent (Begbie). The *lithium salt* has been found to relieve some epileptics better, and in smaller doses than the potassium salt, and to give sleep well (Gibb, 1864; Weir Mitchell, Amer. Journ., ii., 1870). The *calcium salt* is said to be more active than that of potassium, 22 gr. of the former causing sleep when the latter failed (Hammond). The *compound with camphor* (monobromated camphor) reduces heart-action and lowers respiration and temperature like the other alkaline bromides; it is efficient as a sedative in less dose—3 to 6 gr. In the *compounds with morphia and quinine*, Dr. Richardson expects to secure the sedative and tonic effects of these drugs without the unpleasant cerebral symptoms which sometimes accompany them (Med. Times, i., 1871, p. 413). I have found them useful. *Bromhydric acid* is said to produce most of the good effects of alkaline bromides with less depression, and to be more readily borne (C. Wade, M. Fothergill). Its real value is, however, not yet proved.

CHLORUM—CHLORINE, Cl, = 35·5.

Chlorine, discovered by Scheele in 1774, is a greenish gas, irrespirable, and when incautiously inhaled producing injurious irritant effects. It has a peculiar odour; is very soluble in cold water; it bleaches all vegetable colours, and is a powerful disinfectant; under a pressure of six atmospheres at 32° F. the gas becomes a yellow liquid of sp. gr. 1·33. It may be prepared from any metallic chloride (as common salt), but is directed by the Pharmacopœia to be made from hydrochloric acid by the agency of manganese oxide, the oxygen of which combines with the hydrogen of the acid, and sets free chlorine on the application of heat: $4HCl + MnO_2 = MnCl_2 + 2H_2O + Cl_2$.

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LIQUOR CHLORI—SOLUTION OF CHLORINE (CHLORINE GAS DISSOLVED IN WATER).

PREPARATION.—This, the officinal solution, is formed by passing the gas through a wash-bottle into a receiver containing distilled water, which dissolves it.

CHARACTERS AND TESTS.—The liquor chlori is slightly greenish in colour, smelling strongly of the gas, and possessing its bleaching and disinfectant properties—sp. gr. 1·003. On evaporation it should leave no residue.

Under the influence of light, chlorine slowly decomposes water with production of hydrochloric acid and oxygen, and the solution then loses its characteristic properties. Hence the advantage of preparing it fresh for use, and the necessity of employing stoppered dark-coloured bottles for preserving it. The *hypochlorites of lime, soda, and potash* owe their special properties to the presence of chlorine, and, as commonly met with, are mixtures of hypochlorites and chlorides, and are known by the name of the latter, as "chloride of lime," "chloride of soda," etc. A solution of the soda salt is known as "Eau de Labaraque," from the chemist who popularized it, and a solution of the potash salt is the "Eau de Javel" of Parisian laundries. Under the influence of feeble acids, *e.g.*, the carbonic acid of the atmosphere, these salts evolve free chlorine until wholly decomposed.

The main chemical character of chlorine is its energetic affinity for hydrogen, which gas it will abstract both from its aqueous and gaseous combinations. In contact with organic substances it is inactive if they are quite dry, but if any moisture be present, nascent oxygen, or ozone, is liberated under the action of chlorine, and destroys or assists the combustion of the organic compound. A concentrated solution destroys the lower forms of organic life, and the gas brought into contact with sulphuretted hydrogen decomposes it, hydrochloric acid being formed, and sulphur precipitated. Hence chlorine is a good disinfectant and deodorant, but limited in its power, for after it has once caused the oxidation of organic matter, or become changed into hydrochloric acid, its disinfectant qualities are almost lost; also its strongly corrosive action limits its use.

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ABSORPTION AND ELIMINATION.—Chlorine gas may be absorbed through the lungs, as proved by finding its odour in the brain after death from its inhalation (Cameron). A dilute solution when swallowed combines with the alkaline salts, either in the stomach or the blood, to form chlorides, and as such passes out, mainly by the kidneys. Husemann suggests that hydrochloric acid rather than chlorides may be formed from small doses.

The hypochlorites, decomposed in part by the gastric acid, give off free chlorine, and then passing into the circulation, are excreted as chlorides of potassium and sodium. Kletzinski ascertained this, and taking himself for a fortnight a daily dose of 60 gr. of "chloride of soda" (hypochlorite), found an increase of 30 to 40 gr. of sodium chloride in the urine (Canstatt-Jahrb., 1851, Bd. i.). Some amount of free chlorine would also seem to pass in that secretion, for after absorption of the gas (in a chlorine bath) Wallace found the urine to possess bleaching properties, though neutral to litmus paper.

PHYSIOLOGICAL ACTION. — *External.* — Chlorine acts as an irritant, causing, when applied in vapour or strong solution to the skin, a sense of prickling, with perspiration, congestion, and sometimes erysipelatous, papular, or vesicular eruptions. Chlorine water long applied causes a fatty degeneration and peeling off of the upper layers of the cuticle (Bryk).

On denuded surfaces or mucous membranes the irritant effect is still more marked—the liquor sodæ chloratæ, for instance, if applied too strong to the throat or vagina, causes much discomfort. The vapour, if much diluted with air, may be breathed without other symptoms than a sense of heat and subsequent increase of expectoration; but if breathed in full strength, it acts as a violent irritant to the respiratory tract, causing spasms of the glottis, convulsive cough, and a sense of severe constriction and suffocation. Death may follow from inhaling an atmosphere of only 1 per cent. chlorine, not from convulsive closure of the glottis, as formerly thought, but from the intense irritation excited, as shown during life by the pain, cough, bloody sputa, etc., and after death by the secretion in the finer bronchi,

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hepatization of lungs, and (seldom) tracheal croup (v. Hassell and Mulder, Eulenberg).

Some degree of *toleration* of chlorine may be established, for in bleaching works the men can remain many hours where a stranger is at once attacked with coughing and irritation.

PHYSIOLOGICAL ACTION.—*Internal.*—The general systemic action of chlorine is that of a *stimulant*, more or less in degree, according to the quantity absorbed; and there is no sufficient evidence of the calmative properties described by Albers.

Circulatory System.—Brought into contact with blood-serum, it coagulates the albumen, loses its characteristic odour, and forms, after a time, hydrochloric acid. In animals dying under chlorine-inhalation, the blood becomes dark red, thick and finely granular, from similar coagulation of albumen (Eulenberg). A solution injected into the jugular vein destroys life with symptoms of asphyxia, and the blood then also is found dark red, but fluid (Nysten).

In man, normal circulation and respiration are quickened under the moderate influence of chlorine. Husemann, however, states that in typhus fever the pulse and temperature become lower under it, and he connects such effect with conversion of the remedy into hydrochloric acid.

Digestive System.—The same observer traces to this acid-change also, an increase of appetite and digestive power, but an excessive dose deranges the stomach. Workmen exposed to the fumes of the gas suffer from acid dyspepsia and various symptoms traceable to gastric irritation; it is not likely that any *blood-change* should occur from continuous exposure to the dilute gas, but it is possible that some local solution of gastric epithelium may follow the constant contact of hydrochloric acid formed and swallowed in the buccal secretions.

Glandular System.—Nutrition.—Chlorine has been credited with a stimulant action upon the liver and kidney. Kletzinsky asserts that the excretion of urea is increased under its use, and Gubler has observed emaciation, implying increased tissue-change. Husemann only remarks that its power of stimulating the hepatic and renal functions "requires confirmation." The

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fæces are said by some observers to become light coloured under its use, suggesting an alteration in, or lessened secretion of, the bile.

SYNERGISTS.—Antiseptics and deodorants.

ANTIDOTES AND INCOMPATIBLES.—In *gaseous* poisoning by chlorine chemical antidotes are—Sulphuretted hydrogen, which forms hydrochloric acid (itself, however, corrosive to the bronchi); ammonia, which forms a chloride of ammonium; and solutions of anilin (Husemann), which also coagulate albumen and are caustic. Probably the best remedy is steam-inhalation.

Poisoning by the *solution* is best treated by albumen or milk with magnesia. Kastner says alcohol and sugar are useful. For medicinal purposes, prussic acid and vegetable coloured infusion should not be prescribed with it.

THERAPEUTICAL ACTION. — *External.* — **Aphthæ — Angina.**—As a local detergent and disinfectant, chlorine solution is very serviceable. In cases of aphthous stomatitis I have known it quickly relieve when borax has failed.

In ulceration of the fauces, whether scarlatinal, septic, or syphilitic, a gargle containing about ½ dr. of liquor chlori in 6 oz. of water, is one of the best for removing unhealthy discharge and slough: in salivation also it is useful.

Wounds—Chancre.—A lotion containing chlorinated soda or liquor chlori, about 1 part in 12 of water, is a good dressing for unhealthy suppurating wounds, and for chancres.

Purulent and Fœtid Discharges.—An injection prepared with the chlorine solutions (1 part in 12) is effective in cases of offensive lochia after delivery, during puerperal peritonitis, etc. I have found it act better than Condy's fluid, but it produces some dryness, smarting, and irritation, if used too strong.

If an injection be required in **Chronic Empyema**, one with chlorine is very suitable, and freer from risk than some other remedies. In **Gonorrhœa** injections of chloride of lime have proved curative.

As a *disinfectant* for the hands after dissections or post-mortem examinations, liquor chlori is efficient. This was proved on a

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large scale some years ago at the Vienna Maternity Hospital, when the students were accustomed to pass from the necropsies to the bedside. At one time the mortality amounted to 30 per month, but after the introduction of a chlorine wash for the hands, to be used before and after every post-mortem examination, the mortality fell to about 7 per month, the ordinary average (Med.-Chir. Trans., vol. xxxii.).

As an aerial disinfectant, the value of chlorine has been variously estimated. When cholera appeared in 1830 and 1831, chlorine-fumigation was officially ordered for clothes, wool, and other imports, but there was no satisfactory proof of its efficacy. The Board of Health reports of that period, with the evidence of Gregory, Tweedie, and others, rather negative its value in limiting the spread of fever; and Bousquet reported that chlorine would not prevent the activity of vaccine virus (Lancet, ii., 1831).[1] On the other hand, Schœnlein and Eisenmann report its value in scarlet fever, and more recently, Dr. Peter Hood expresses great confidence in it in this disorder. He uses towels and sheets wrung from a strong solution of chloride of lime, and placed about the room and before the door: he states that he has never known infection spread when this was practised. Internally he gives, at first, a purgative or emetic, and afterwards quinine, with the best results (Lancet, i., 1869). Mr. Stone (Manchester) reported the vapour effective in staying the spread of cattle plague; he disengaged it by dropping a few grains of chlorate of potash into a wine-glass two-thirds full of muriatic acid, every six or eight hours; and invented an arrangement for the continuous and regulated supply of the gas in hospital wards, etc. (Lancet, ii., 1867).

The general opinion of the profession, and the general result of experiment, is rather against the possibility of controlling infection by this means, at least by a chlorinated atmosphere dilute enough to be respirable; it must be considered doubtful whether emanations from vessels containing lime chloride,

[1] Dr. Baxter has shown, however, that chlorine, added in quantity sufficient to render the lymph acid, abolishes its infective power, and in the same series of experiments found that chlorine in the proportion of ·078 per cent. or more, is equally antidotal to the virus of infective inflammation (Report of Med. Officer of Privy Council and Local Gov. Board, new series, No. vi.).

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or from sheets saturated with it, really exert a remedial effect, though as a measure of precaution they may be worth using. In an empty closed chamber, the gas, no doubt, is effective, and may be used as described under manganese, but for general purposes sulphurous acid is better.

Phthisis.—The literature of forty years ago contains many cases of phthisis treated apparently with benefit, both in France and this country, by inhalation of chlorine.

Elliotson recorded some advantage from it, and I remember Sir James Simpson speaking well of the method, and pointing out that bleachers did not usually get phthisis, and that the air of bleaching works was found to cure cough. Further experience has not corroborated the expectations formed, although in cases of offensive and copious expectoration some benefit may be derived from chlorine-inhalation.

In **Bronchiectasis** and **Gangrene of Lung**, chlorine-inhalations may certainly give much relief by their stimulant and disinfectant power.

THERAPEUTICAL ACTION.—*Internal.*—**Chronic Hepatic Congestion.**—On the hypothesis that chlorine stimulates the biliary flow, liquor chlori has been given internally in hepatic congestion, and Wallace wrote in favour of vapour baths containing chlorine. It is one element, at least, in the benefit often given by nitro-muriatic acid, internally or in bath; but chlorine alone is not depended upon in modern practice.

In **Scarlatina**, the liquor chlori has been recommended, and acid solutions of free chlorine; but I think there are better remedies.

PREPARATIONS AND DOSE.—*Liquor chlori:* dose, 10 to 30 min., freely diluted. *Vapor chlori* (inhalation of chlorine): take of chlorinated lime 2 oz., water (cold) a sufficiency; put the powder into a suitable apparatus, moisten it with water, and let the vapour that arises be inhaled.

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AQUA—WATER, H_2O, = 18.

Pure natural water is a limpid, colourless fluid, free from taste or odour. When evaporated, it should leave no residue. In the Pharmacopœia it occurs as "aqua destillata—distilled water," but ordinary water is much more extensively used in practice.

ABSORPTION AND ELIMINATION.—Water is readily absorbed into the blood, and especially so if the normal systemic amount has been temporarily lessened by excessive excretion of urine, perspiration, hæmorrhage, etc. When the system already contains a normal amount, then an extra quantity is less readily taken up. Elimination occurs by the kidneys, the intestines, the skin, and the lungs, and of any given portion it is commonly completed within six hours, though during strong exercise the muscles retain liquid for a longer time. Of that taken, the greater part passes out by the kidneys, augmenting their functional activity and carrying off a proportionately increased amount of urea, phosphoric acid, and sodium chloride. If the extra quantity of water taken be within moderate limits the increased elimination is accompanied or soon followed by increased absorption.

PHYSIOLOGICAL ACTION.—*External.*—This varies much according to the form of application, whether in large or small quantity, by douching, immersion, or wet sheets, etc.; and again according to the *temperature*, cold, tepid, or warm, and according to the shorter or longer time during which the patient is exposed to it. It is desirable, therefore, to consider, in some detail, the different modes of its application.

The Cold Bath.—Temperature from 40° to 60° F., according to the season. What is said under "sea-bathing" (*v.* pp. 194, 195) applies almost equally to the ordinary cold bath taken with a plunge. There is a sudden feeling of chilliness with roughening of the skin (goose-flesh), some blueness of lips, catching of breath, and lowering of pulse. But in a few moments, in fairly healthy persons (and only such should take this form of bath), "reaction" sets in, with sense of warmth and exhilaration,

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quickening of pulse and respiration, and augmented muscular power. The first effect is due in part to altered conditions of circulation (the superficial vessels being for the moment emptied, and the internal vessels congested), and in part to the sudden shock felt by the large peripheral expanse of sensitive nerve-tissue in the skin. That the nerve-centres can transfer and transmute the sensations and effect of *cold*, as well as other sensations, might be taken for granted, but a familiar illustration of the fact is presented when one hand only is immersed in cold water, and the sensation is transmitted to the cord and brain, and thence *reflected* to corresponding nerve-connections on the opposite side, so that the temperature of this opposite limb is also lowered. That the blood-supply of internal organs may be controlled by external applications is proved, *inter alia*, by the observed contraction of renal arterioles when ice is applied to the lumbar region (Brown-Séquard), and by the immediate diminution of the volume of a congested liver and spleen under the influence of cold douching (Fleury).

The general effect of a short and satisfactory cold bath is "tonic." The blood circulates more freely, and tissue-change is increased; yet, concurrently, appetite and digestive power are so far improved that during a course of such baths weight is commonly gained.

The *too-prolonged* cold bath, used only through imprudence by the healthy, or for definite curative results in the hyperpyrexial patient, has a very different effect. The primary reaction is succeeded by coldness, depression, weakened circulation, and an exhaustion which may progress to collapse. The temperature is steadily lowered, the blood accumulates in the great venous trunks, capillary circulation and tissue-change generally are interfered with, and reflex symptoms, such as nausea, vomiting, and syncope, may follow. Pugibert and Bailey have lately described a scarlatiniform flush, limited or diffused, as occurring from the cold bath. According to two cases reported by them, this rash is the precursor of shivering, lividity, and a syncope which might prove fatal if it occurred in deep water (Med. Record, Aug. 15, 1879). In the clinical use of the cold bath such results are avoided by careful watching and thermometric observation.

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Intense cold is an *anæsthetic;* a mixture of ice and salt applied to the skin for a few moments causes it to assume a white or leaden hue, and in this state incisions can be made into it quite painlessly; the rapid evaporation of ether thrown on to the part in fine spray is also used to produce the same effect.

Wet Towels—The Wet Sheet.—A milder method of using cold water is in the form of towels, or a sheet, wrung out, and applied with vigorous friction; it is free from the risk of serious shock to delicate subjects, and is commonly and properly applied before commencing with cold immersion.

The *towel friction* is given first to the upper part of the body whilst the patient sits with the lower limbs still covered—that is to say, the whole surface is not exposed at one time. Where there is a very feeble state of circulation, or when the breathing is much oppressed, the water may at first be at 80° or 90° F., and gradually lowered to cold, and more of it left in the towel as the power of reaction improves. Under this "graduated stimulation," a pale, bloodless, and sensitive skin may be educated to a good power of reaction, with marked relief to chilliness and to the frequent recurrence of catarrh, and there are scarcely any patients—certainly none who retain the power of taking and digesting food—that cannot receive towel-rubbing with advantage. In catarrhal subjects, however, special care should be used in avoiding exposure at first, or harm may result.

The *wet-sheet friction* is somewhat more trying, since it should always be used cold, and the patient stands, quite uncovered, whilst the sheet is thrown over the shoulders and round the whole body, and friction is applied by making folds in the sheet, not by simply rubbing the smooth surface. This should be continued for two, three, or four minutes. It is suitable for persons not much accustomed to cold water, but with a fair amount of vital power. "It rouses all the activity of the nerves and blood-vessels of the skin, without taking much animal heat from, or calling for much organic exertion of the frame, and whilst doing this it transmits to the nervous centres the genial stimulation which it impresses on the great nervous outer covering of the body" (Gully). It relieves fatigue, and may be taken when a cold bath would be unsuitable; it relieves, also, nerve-depression and early stages of catarrh and neuralgia. To

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use a warm sheet, unless followed by a cold one, is not attended with any of the good effects of this kind of bath; by a sheet so wet as to be "dripping" a more powerful effect is exerted, whilst by wringing the sheet very dry from the cold water, quicker reaction will be ensured. The patient should not attempt to rub himself much, or make any violent exertion during this process, otherwise he may be annoyed by giddiness or palpitation.

Shallow Bath.—This is given with about six inches of water in a bath long enough for the patient to sit, with the legs in, though he need not lie down. The water should be splashed, and rubbed, and thrown over the body by means of a towel used by an attendant at the back, while the patient splashes his front for from one to five minutes, according to the reactive power. The frequent change of the splashing water against the body lowers temperature for the moment, and vigorous friction is required afterwards, or walking exercise. The same bath, more or less completely given, is the ordinary morning "tub" of average Englishmen, and exerts an excellent tonic and anti-catarrhal effect. During acute febrile disorder the shallow bath may be used at 70° to 80° F., and much exertion is not desirable, nor is friction required; but in the absence of acute disorder it should always be taken cold in summer, or at about 60° F. in winter, and be followed by exercise. Its ultimate effect is to equalize circulation, but it encourages it especially in the lower extremities, and so relieves the head and the viscera.

The Pail Douche is administered by throwing two to four pails of water (six or eight gallons at a time) over the shoulders, against the back, or the front of the chest, as the patient sits in a long bath. A dry towel friction follows. This process adds the shock of dashing water to the splashing of the shallow bath, and imitates to some extent the wave-stroke of the open-air sea-bath. It needs more power of reaction than the baths already mentioned, and, if well borne, has much more effect in relieving internal congestion, whether of the liver, the uterus, or the nerve-centres. The amount of force used, and the number of pails, should be varied with the vital conditions of the patient. In chronic hepatic and cerebral congestion, usually much force will be borne.

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Spinal Washing.—This is a mild and local form of douching from a jug, or can, or large sponge, emptied along the spine as the patient sits on a board placed across the front of a bath. It may be continued from two to ten minutes, and sometimes should be commenced at 80°, and gradually cooled down, until after a few baths it can be borne wholly cold. If commenced too cold, in sensitive subjects it may give rise to headache or giddiness, and if continued too long may induce a rheumatic condition of the back-muscles, and is not free from risk to the kidneys. It would seem that the spinal cord is directly stimulated by the shock of cold water, and that the stimulus is reflected to peripheral and visceral nerves; hence, according to hydropathic authorities, "a divergent effect on the action of the heart, stomach, kidneys, uterus, etc." It is probable, also, that the sympathetic ganglia are directly stimulated, and this bath is useful in functional torpor, marked by numbness or slight paralysis of limbs, constipation, and phosphaturia, etc. Certainly, a very bracing effect and pleasant glow may be produced by a moderate cold wash to the spine, followed by manual friction, and the effect may be further developed by the use of a "rubbing wet sheet" to the whole surface for a few minutes afterwards.

The Douche.—This bath is the most powerful and the most important within the domain of hydro-therapeutics, and has been made the basis of the system practised with much success by Dr. Fleury, at Bellevue (Paris). Its effect varies with its size, force, direction, duration, and temperature. It may be a column of water from one to three inches in diameter, falling twelve to twenty feet, or propelled at right angles to the patient's body. It may be broken up into fine streams by a rose, or into more numerous jets, arranged to play at once on the body from different quarters (*douche du cercle*—needle douche). Again, it may be used tepid, hot, or cold, or all three at one sitting, and its duration may vary from ten to sixty seconds, or in healthy people more.

The cold douche should be commenced cautiously, after due estimation of the patient's reactive power, and if there be much debility, it should be applied at first to the extremities only, and for a very brief period—ten to fifteen seconds: this is a most

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important point: it should never be applied to the head. In disease, the douche is, as a rule, suitable only for chronic cases, but with careful management may be applied to almost all conditions.

According to Dr. Howard Johnson, the cold douche markedly increases the respiratory acts, and "thereby imparts an enlivening influence to all the vital phenomena." "It is a diffusible stimulant, and is comparable to ammonia," though it does not always quicken the pulse. According to Fleury, the general douche, in shower, jet, or circle, is powerfully tonic and reconstitutive, by virtue of its action on the circulation. With an increased force of percussion, rapid movement from one part to another, and fine division of the liquid, a more exciting effect is produced. By directing the stream upon various parts in such force as to congest them, a revulsive action is made to relieve the congestion of other parts; thus, metrorrhagia and vomiting, even when dependent upon a uterine polypus, have ceased under a course of cold douching (Fleury, third ed., p. 297), and the volume of the liver and spleen has markedly diminished. Andral and Piorry verified the extent of hepatic dulness in a certain patient as 18 centimètres (vertical) and 11 centimètres to the left of the median line (horizontal), and agreed that immediately after an energetic douche, the former measurement was reduced by ½ centimètre, the latter by 5 centimètres; and in another case, the spleen, which measured at the commencement of treatment 23 centimètres vertically and 15 transversely, measured only 9 and 7 centimètres respectively after six days of repeated local douching. The effect on other organs is similar, though less rapid. But in chronic cases, it is important not to induce such results too quickly, since fresh and more serious congestion may be produced elsewhere.

In certain disorders, such as dropsy or effusion into joints, *absorption* has been markedly stimulated by the douche (Fleury).

The Sitz Bath.—A valuable influence may be exerted not only on the pelvic organs, but indirectly on the whole system, by sitting in water of varying depth and temperature (60° to 80° F.) and for a time varying from 5 to 30 minutes. "The immense network of nerves which supplies the whole of the organs con-

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tained within the hips and the lower belly, and the lower third of the spinal cord, terminating in great leashes of nerves, are the sensitive points upon which the sitz bath operates" (Gully). It certainly "draws blood from the brain," and is one of the best means of insuring sleep. It relieves fatigue, improves appetite and digestion, lessens headache and giddiness, regulates the bowels, and the uterine flow, and the action of the kidneys, often augmenting them when deficient, or lessening if excessive.

To obtain these good effects it is most important that thorough reaction be secured by friction or exercise, or warm clothing, otherwise shivering and depression come on. It may be advisable to commence with *tepid* water, or a more powerful stimulus may be given by a "running sitz," fresh cold water constantly entering the bath and circulating round the body. Or again, a local douche may be made to act upon the lumbar region, the perineum, the uterus, etc., whilst the ordinary sitz bath is in progress. The *general* effect of the cold sitz bath is *sedative*. It slows the pulse to the extent of 10 or 15 beats during the first five minutes—of 20 beats in the course of half an hour (H. Johnson). It also lowers the respiration, though very slightly, and it lessens the body temperature. By its rubefacient effect, the sitz bath acts also as a derivative or counter-irritant.

Foot-Baths.—The immersion of the feet produces some of the effects of the sitz bath, but in a minor degree. It lessens the amount of blood in the cranial circulation and relieves flatulence and slight visceral congestions. For all purposes, the thorough-going hydropathists use foot-baths *cold*, or at least cool, with considerable friction, but there are some subjects in whom the *cold* to the feet produces serious symptoms, and others—such as the gouty and catarrhal patients—in whom a *hot* foot-bath, to which mustard or pepper may be added, relieves, and under due precaution as to exposure, does so more pleasantly and effectually than the cold. Friction of the feet with a "damp or dripping towel" is, however, an intermediate method often available.

Wet-Packing.—This is a still more sedative process than the sitz bath, since it is applied over a larger surface, and involves complete rest. To avoid unduly rapid depression of circulation and general activity, it is often advisable to commence with a *partial* packing, *i.e.*, closely applying to various

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parts folded towels wrung from cold water, and covered with flannels and waterproof sheeting. Thus the hips and loins may be "packed" from the level of the navel to half-way down the thigh; the abdomen, from the lower edge of the ribs to the hips; the chest proper, over the ribs, or the whole front and back of the body: it is said that packing applied to the chest exhausts more than packing of other parts of the body (Gully). Again, packing of the lowest part of the belly and back, of the whole spine, or of the sides, are other varieties: the wet towels may be changed every fifteen to twenty minutes for an hour or two.

The complete general pack is applied by covering the whole body with a wet sheet, and this with several blankets, the patient lying thus covered for about one hour. This process lowers the pulse and temperature and weight, and is compared by Johnson to antiphlogistics, leeches, calomel, and antimony. It may be used at once in chronic cases in sanguineous irritable subjects, but should be practised with caution in anæmic weakly persons. It usually, though not always, induces moderate diaphoresis, and it should be followed by a shallow bath of two to four minutes' duration, and then friction. The water, urea, and chloride of sodium in the urine, are increased under the use of the wet-pack—slightly so from a moderate use of it, considerably if it be continued from three to four hours.

There is more discomfort, with chilliness and depression, produced by the routine use of this agent in hydropathic establishments, than by any other measure. In febrile conditions it may be of the utmost value, but even in such cases I have seen serious results from the exhaustion induced.

Compresses are partial packings, and exert a marked local soothing effect. "They serve both to prevent and to relieve irritation," and much misery of indigestion and of torpid bowels is avoided by the almost daily use of a compress over the stomach. Various forms of joint-pain may be relieved by the cold compress, and a similar application to the epigastrium will often induce sleep in cases of insomnia from excessive brain-work or anxiety.

The frequency of changing the cold wet cloth must vary with the effect desired. *Soothing* is not induced till a certain

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amount of heat is withdrawn from the part, and if the compress is allowed to get too warm it is apt to *stimulate* and irritate. In acute bilious attacks, the stomach-compress should be changed about every two hours (Gully); in chronic gastric irritation, five or six hours will be a suitable time, and in chronic pulmonary disorder, eight or ten hours; in inflamed throat, every six or twelve hours; in contusions, every half-hour, whilst in congestions, such as of the testicle from sexual irritation, or of the uterus, every five minutes change for one to three hours gives most relief.

Preissnitz, Fleury, Gully, and others strongly object to compresses being applied warm, but I have often found them useful.

Warm Baths.—By an action contrary to that of cold baths, these *attract* the blood *primarily* and directly to the part exposed to their influence, relaxing the vessels and tissues, and leaving them afterwards in a condition of lessened tonicity. A similar effect is exerted by all kinds of warm baths, but it differs in *degree* according to the temperature and duration. By a *tepid* bath is meant one at from 70° to 80° F., and this is chiefly used for cleansing and moistening the skin—a temperature of 92° to 98° F. gives a *warm*, and upwards to 112°, a *hot* bath. With the former there is at first a pleasant sense of soothing and refreshing warmth, the skin reddens, and the pulse quickens in frequency, whilst it lessens in tension; the respiration is also quickened, and the temperature rises. If the bath be too prolonged, a sense of languor comes on, and after it there is less aptitude for exertion than before. Under favourable conditions, excretion is increased from the skin, the kidneys, and the lungs, at the time of the bath, and oxidation is lessened subsequently.

In a Hot Bath, 98° to 112° F., the first sense of heat may be painful rather than pleasant, then a general stimulating effect is perceived, the whole surface becomes deep red, and the cutaneous veins distended; relief is thus given to internal congestion, to pain, and muscular spasm and convulsion. Complete muscular relaxation follows, with greatly diminished tension of the pulse, and increased frequency of heart-action; before very long, a sense of oppression and distension may be felt in the chest and head with general languor, giddiness, or faintness

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from paralysis of vaso-motor and cardiac inhibitory nerves. These unpleasant effects occur much sooner in some persons than others.

By a hot bath perspiration is usually, but not always, increased; and sometimes from the high temperature of internal organs a restless, heated condition similar to that of true pyrexia may be induced for a time. This may be noticed, especially after a too-prolonged use of the hot strong saline baths (Droitwich, etc.).

The length of stay in a hot bath should depend on the purpose to be accomplished, whether (1) mere excitation of circulation in the skin (which is effected by a short bath with or without the extra stimulus of salt or mustard), or (2) perspiration and relief of pain (which require, perhaps, half an hour), or (3) complete muscular relaxation (which needs a prolonged immersion). In contra-distinction to the ultimate tonic effect of the cold bath, decided loss of weight results from a course of warm bathing (A. Steffen).

Contra-indications.—Since the thoracic organs and the brain become more or less congested during a hot bath, its prescription needs as much caution as that of cold bathing, though for a different reason:—pulmonary or cerebral vessels may even give way, especially if the latter be atheromatous. According to Dr. Steffen, hot water baths are pre-eminently contra-indicated by congestion or œdema of the lung, and Dr. H. Wood has seen under such conditions, "the most frightful dyspnœa result." In such an accident, cold affusion should be freely used.

Hot Fomentations.—As cold water may be usefully applied in local compresses, hot water is often of the greatest service applied in fomentation, *i.e.*, when a thickly-folded flannel, or any thick absorbent substance such as spongio-piline, is completely wrung out of hot water, and placed on the affected part, covered with dry flannels, oil silk, or mackintosh outside, to prevent evaporation and retain heat, and changed again frequently, the process being continued for half an hour, or even for several hours if necessary. This stimulates the external skin much more strongly and suddenly than any cold compress, for every degree *above* the normal skin-temperature is felt much more acutely than every degree *below* it (Gully), and it acts much better than the more equable heat given by hot salt,

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hot bran, or tins, or caoutchouc bags of hot water, because the high temperature is more constantly renewed.

If there be congestion, or even inflammation of an internal organ, it may be relieved by such external application which is especially indicated when the patient is too feeble to react to cold, or when the pain and irritation are very severe, and "of the mingled nervous and inflammatory kind, with, if anything, an excess of the former." The direct application of quite hot water causes contraction of small vessels and also of the uterus.

Steam-Baths.—The vapour of water, in the form of the steam-bath, lamp-bath, hot wet-packing, or Russian bath may be used to accomplish still more thoroughly the same objects as those to be expected from the warm or hot bath. In one good form of vapour-bath, the patient sits unclothed in a chamber to which steam is admitted, but the head is outside, covered with a cold cloth. In a less complete, but more portable form, the patient sits on a chair covered with blankets, whilst steam is generated by a spirit-lamp placed under a pan of water: or a somewhat similar result may be obtained by dropping freshly-burned lime into a bucket of water under the chair, or a heated brick into hot water; or if the patient be too weak to rise, steam may be conducted under the bedclothes raised by hoops; or a heated brick, wrapped in moistened cloths and flannels, laid near each limb. The most complete form of such bath is, however, the Russian bath, which is given in a closed chamber filled with steam. On first entering the bath there is often a disagreeable sensation of heat and burning in the skin, the pulse becomes quick, and respiration uneasy; sometimes there is a feeling of pressure on the eyes, heaviness in the head, and dizziness; but these symptoms soon pass away, and the respiration becomes more natural and deeper, the blood finds easier access throughout the body, the skin soon gets red and moist, and the patient comfortable.

Eulenburg states that the steam-bath raises the body temperature to a very appreciable degree; on an average a steam-bath of 41° to 42° C., by 1¼ to 1½ degrees C. (Real-Encyclopædia, 1880, i., p. 708.)

Turkish Bath.—In conjunction with other baths should be considered the Turkish, or Anglo-Turkish bath, in which dry

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air at a temperature of from 100° to 160° F., or more, is employed, the patient passing through graduated chambers during 20 to 40 minutes; when free perspiration has occurred, and lasted for some time, shampooing is commenced, and afterwards the body is washed with copious lathers of soap and streams of water, warm, tepid, and finally cold. The effect of the warm applications and frictions is to stimulate both the general and cutaneous circulation, to relax the muscular tissue, relieve pain and congestion, to cleanse the openings of the skin-glands, and to eliminate through them morbid material and retained excretion. That the skin excretes urea has been proved by finding it in the perspiration of healthy persons (Landerer, Funke, Leube, etc.); but still more constantly in cases of scarlatina, nephritis, cholera, collapse, and chronic Bright's disease (Scottin, G. O. Rees, Fiedler, etc.) In such cases the urea may even form a crystalline powder on the skin, especially near the sweat-glands (H. Wood). Moreover, in diabetes the perspiration contains sugar; in rheumatism, lactic acid; in gout, uric acid; and in jaundice, biliary products. This being so, it is evident that the promotion of very free secretion from the skin-glands by the varied processes of the Turkish bath is a most efficient means of depurating the blood. The effect of the final cold douche or plunge is to contract muscular tissue both in the skin and deeper parts, and to stimulate and brace up the nervous system; hence this form of bath combines the good effects of both hot and cold applications. It should induce an agreeable sense of vigour and elasticity, and render the skin less sensitive to changes of temperature.

It does not, however, always succeed well; in some subjects, especially at first, sweating is not favourably induced, and they suffer from heat, malaise, and headache; the use of a wet towel with friction should then be tried, or gentle douching with warm water on first entering the bath; drinking cold water is also recommended for increasing the skin secretion, and often succeeds, but in my experience it has sometimes caused nausea and gastric pain.

Persons vary in their power of resisting heat, and although there are really few who cannot go through a Turkish bath with safety, there are many who suffer at first with some degree of

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oppression, faintness, and exhaustion. Hence, the first bath should be taken cautiously, not prolonging unduly the time in the hot chamber—say not beyond 20 to 30 minutes (the sensations will practically guide as to time), and finishing with the cold or nearly cold douche for a few seconds only, not with the plunge bath. It is a mistake to go over-fatigued into the Turkish bath, or within three or four hours after a good meal; or to dress too hurriedly, and go with still-perspiring skin into the open air.

Contra-indications to this form of bath are to be found in extreme debility from any cause, and in some conditions of pulmonary congestion or tendency thereto: chronic heart-disease *per se* does not necessarily negative the bath, but requires extra precaution.

Dry or Blanket-Packing.—In this process the patient is enveloped in six blankets, one at a time, each accurately adjusted about the throat and feet, so as to be air-tight; a feather bed is thrown over all. Dr. Howard Johnson speaks highly of this treatment, which he credits with producing the same results as vapour or Turkish baths, without so much general perturbation. After a time, the air next the skin is so far heated as to excite the circulation, and stimulate a flow of perspiration, and after this has lasted for half an hour or an hour, a shallow bath at 70° or 60° F. and a dry friction complete the process.

Though weight is temporarily reduced and excretion increased by this, as by other warm baths, it does not necessarily follow that the general condition is impaired; on the contrary, in satisfactory cases, even after profuse sweatings, weight is ultimately gained owing to increased appetite and assimilation.

Mustard-Bathing or Packing.—Mr. S. Newington has drawn attention to the powerful derivative effects of the hot mustard-bath. Two handfuls of mustard powder are tied in a cloth, and pressed in hot water till a very strong extract is obtained, which is mixed with the water of a full hot bath, and after the patient has entered this (the genitals being protected by a folded towel), a blanket is laid over the bath to prevent irritation of the eyes. After five to ten minutes' stay the patient is dried and goes to bed. A similar but milder application is that of a sheet wrung out of mustard infusion and

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covered with waterproof. The effect is to strongly excite the capillary circulation in the skin, and so to relieve internal congestion, especially of the nerve-centres, and hence it greatly disposes to sleep and quiet in conditions of mental excitement. Under packing of the trunk in towels wrung out of the hot infusion the pulse came down from 108 to 60 per minute in the course of two hours (Lancet, i., 1865).[1]

PHYSIOLOGICAL ACTION.—*Internal.*—Water is an essential constituent of the animal tissues, and their healthy growth is dependent on its sufficient supply. In passing through the system, water (1) assists the circulation of the nutrient fluids; (2) renders oxidation and other chemical changes more active; (3) by its solvent action promotes absorption, secretion, and excretion; and (4) by its evaporation from the surface gets rid of superfluous heat. The tissue-change produced by medicinal water drinking is greater in the young and delicate than in robust adults; it is promoted by increase of temperature whether of the water itself or of the atmosphere; also by bodily exercise (Parkes). The ultimate result of a judicious course of water drinking is increase of weight, and (it is said) of fat (Bartholow), but if an *excessive* amount be taken, the blood is rendered unduly fluid, the corpuscles become paler and less healthy, and general nutrition is impaired.

[1] Schüller (of Laubbach) has studied the effect of various applications of water on the cerebral circulation of rabbits after trephining and removing the cervical sympathetic on one side. Compresses over the abdomen at 50° F. caused dilatation of vessels of the pia mater; a general bath at 50° induced the same effect in greater degree. After similar applications, but quite cold, a gradual contraction of cerebral vessels occurred in five to ten minutes, and lasted for about half an hour. Warm water, 95° to 99°, applied in the same manner caused marked contraction of the same vessels. A douche over the belly and back caused alternating changes. Injections into the rectum induced moderate dilatation. Under a cold pack, gradual and strong contraction occurred, lasting often for two hours, pulse and respiration were slowed, and reflex irritability was reduced. Ice on the head caused, after a time, moderate contraction; friction over abdomen had the same effect. We can scarcely draw definite practical conclusions from these observations, but it would seem that tepid applications over the body lead to *dilatation*, and quite cold or hot applications equally cause *contraction* of cerebral vessels. Schüller considers that extreme degrees of temperature are contra-indicated in cases of hyperæmia, congestion, and anæmia of brain, and that the main good effect of baths is exerted in depleting cerebral vessels, in giving tone to the muscular coat of arteries, and indirectly the cardiac muscle, and thus improving nutrition of nerve-centres (B. M. J., i., 1876).

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Large draughts of *cold* water, especially if taken on an empty stomach or when the body is heated, act injuriously, by giving a shock through peripheral nerves to the abdominal sympathetic, and may cause nausea, faintness, actual syncope, and in some cases even death. Draughts of *warm* water, if not rejected by the stomach, act more quickly than cold upon the skin and the kidneys; they usually *cause* or assist vomiting, but if a pint or more be taken it will often *stop* vomiting by distending and paralysing the stomach. I have also known even a *moderate* quantity of hot water stay vomiting when ice had failed to do so; and again, a small quantity—two or three teaspoonfuls—of quite hot water, taken at short intervals, has arrested reflex vomiting, *e.g.*, after ovariotomy.

A certain amount of fluid taken with meals assists digestion, but too much, impairs it by over-diluting the gastric juice, and hurrying on the passage of the food. Its *temperature* is of importance, for if taken hot, especially with a substantial meal, it is liable to distend and enfeeble the stomach, whilst if iced, it does harm by contracting capillaries and diminishing normal blood-supply, although, indeed, a healthy stomach will tolerate, for a time at least, these and many other injurious things. Warm liquid, such as tea, taken *shortly before* a substantial dinner, will commonly disorder the digestive functions sooner or later, but this is not wholly due to the fluid, but to its astringency, etc., for a warm nutritious soup at the commencement of a meal suits many persons. If they are fatigued, it supplies nourishment in a form which is readily taken up, and enables solid food to be better digested.

Taken later on in the meal, at the end, or an hour or so afterwards, fluids, cold or warm, materially assist completion of the digestive process, and the onward passage of peptones and the other contents of the stomach.

It is well known that water exerts a marked influence on the fermentative process: thus sugar, anhydrous or mixed with but little water, does not ferment at all; with moderate amounts of water the vinous, and with an excess of water the acetous fermentation takes place, and it is very probable that water exerts analogous influences on the food. Bacteria will not develop in a *concentrated* solution of albumen.

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THERAPEUTICAL ACTION.—*External.*—Hæmorrhage.—The application of iced or cold water is an old, and commonly an efficient method of restraining hæmorrhage from small vessels. The jet of water, or the soaked cloth or sponge should be applied suddenly for a few moments at a time. Mr. C. B. Keetley has lately drawn attention to the value of hot water as a hæmostatic, and quotes a case of thigh-amputation, where a sudden drenching with water at 120° F. stopped the bleeding after cold water had failed to do so. He suggests that in such cases it acts as an excitant to the nerves of the muscular coat of the small vessels, and perhaps directly irritates the muscles themselves (Practitioner, Feb., 1879). Dr. Paul Brown found water at 150° F. succeed well in staying hæmorrhage after an amputation when Esmarch's bandage was removed (Med. Record, 1879).

Mr. Keetley has also found hot water efficacious in epistaxis, though he acknowledges that "it is powerless against it if of a certain grade of severity," and I have myself seen its use in a very severe case followed by serious results. During one attack the attendant had applied it for some time, though the bleeding continued, and the patient became alarmingly prostrate. I stayed the flow quickly with cold water, but in a second attack, some weeks afterwards, I heard the hot water treatment was again employed, and the patient died of syncope.

In **Uterine Hæmorrhage** the results of hot water injections have been more satisfactory. Windelband used it at 117°, 120°, 124° F. (Med. Times, 1876). Emmet (New York) and Whitwell found it very safe, efficient, and disinfectant in post-partum hæmorrhage (Lancet, i., 1878, p. 920). Lombe Atthill uses it constantly (at 110° F.) in his practice at the Rotunda, not only in hæmorrhage, but also in chronic uterine congestions. Ricord finds a hot uterine douche, 122° F., "almost infallible" in menorrhagia. C. Richter uses hot douches for hæmorrhage in childbed, and reports 105 cases occurring in the Charité (Berlin) where they had been employed with excellent results; he recommends injections of three to five pints at 122° F. into the uterine cavity through a catheter, and for the sake of disinfection adds a proportion of 1 per cent. of carbolic acid; he says that the hot water coming in continued contact with the inner surface of the uterus causes a soaking and swelling of the tissues, particularly

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of the perivascular connective tissue, and thus checks the hæmorrhage (Zeitschrift für Geburtshülfe und Gynæcologie).

Peter recommends it for cases of non-puerperal hæmorrhage; his theory is that through the irritation of the lumbar ganglia the vaso-motor nerves get into a state of "over-activity," and that the vessels contract accordingly (Centralblatt für Gynæcologie). I have myself ordered hot water injections in several cases of uterine hæmorrhage, directing a stream at 122° F. into the uterine cavity, and the effects have been various. When hæmorrhage arose from cancer, sometimes there was immediate relief, which lasted for some days, but in others the bleeding was increased; when the bleeding arose from a retained portion of the placenta a larger flow occurred; when caused by an atonic state of the uterus the hot water injection alone did little good, but when alternated with cold injections, 60° to 70° F., the result was excellent. In all other cases of hæmorrhage the effect was beneficial. I am satisfied that the water should be as hot as possible, otherwise success cannot be secured; and I agree with Runge in calling it "a non-infallible but an important remedy." It is already largely used in London practice, with very general satisfaction. Hot water bags applied to the lower part of the spine also prove useful in uterine hæmorrhage.

Ulcers, Wounds, Contusions, etc.—The "cold water dressing," with wet lint cut accurately to an ulcerated surface, or amply covering an inflamed part and overlapped by oiled silk or gutta-percha is one of the best, as it is the simplest, application for ordinary cases. In abscess, warm fomentations expedite the pointing and relieve tension, pain, and other symptoms. They are useful in encouraging bleeding from leech-bites, etc., and in assisting the separation of sloughs. In more severe wounds, if there be much heat and irritation, it is well to keep the dressing constantly moist, uncovered by waterproof, and the most complete method of doing this is by *irrigation* from a can of water over the bed—a small stream percolating the dressings, and draining into a basin on the floor. On the other hand, sometimes, the cold water treatment of wounds is too depressing, and leads to slowness of repair, or sloughing, and the hot water dressing or immersion has been recommended in such cases, especially by Professor Hamilton (New York) and some other

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American surgeons. If recent lacerated or incised wounds of unhealthy character are kept constantly under hot water (95° to 100° F.), there is a sense of comfort induced, not absolute relief from pain. On the second or third day, the parts adjacent are swollen, but not much reddened; the integument is sodden and white. On the fifth day or later the swelling is sometimes great, and the granulations covered with a white exudation, but the area of acute inflammation is much limited; erysipelas and gangrene are arrested or restrained; traumatic fever has seldom, and septicæmia has never occurred in any case in which submersion has been practised from the first day (New York Med. Record, May, 1874). Of course, simple incised wounds and healthy amputations do not need such an elaborate method of treatment.

Hot water is very useful in the treatment of recent sprains, the affected limb being immersed in it at the highest endurable temperature for about 15 minutes (Med. Record, 1879).

For **Burns, Cellulitis, Sloughing Phagedæna, Sloughing and Phagedænic Chancres,** immersion in the hot bath is extremely efficacious, relieving pain, limiting the disease, hastening separation of the sloughs, cleansing the wound, etc.

Hernia.—A bag of pounded ice placed over a hernial protrusion has caused its reduction; the cold lessens the volume of the contents of the gut, especially of the gases; it also stimulates peristalsis, and causes contraction of vessels.

Heat also is used for hernia by fomentation, or better, by the hot bath. It relieves pain, allays spasm of muscles, and so favours reduction: the taxis should be employed while the patient is in the hot bath, which should be continued until muscular relaxation is complete.

Stricture—Retention of Urine.—A lump of ice introduced into the rectum is a favourite remedy for retention of urine. Immersion in a hot bath, by relieving deep congestion and allaying muscular spasm, is very useful in similar retention, especially when due to congestive or spasmodic stricture, or to either of these conditions, added to organic stricture. The application of a hot sponge or fomentation to the genitals and hypogastrium is the simplest way of relieving "nervous" retention.

In **Orchitis,** iced water made to circulate through a tube coiled round the affected testis will often relieve pain instantly,

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and entirely cut short the attack. It should be applied early. A similar coil applied to the penis has been introduced by Dr. Otis for the treatment of hæmorrhage from the urethra after internal urethrotomy.

Bubo—Hæmorrhoids.—In these maladies also the application of ice or cold water is often servicable. At other times hot fomentation gives more relief, as it may do in orchitis.

Varicocele.—Suspending the scrotum in cold water night and morning, braces up the dartos and the muscular tissue in the veins, and relieves this malady.

Vesical Catarrh.—Warm hip-baths are of much value in this condition, and may be employed two or three times daily, for half an hour or an hour at a time. In gonorrhœal inflammations and discharges they are also good.

Catarrh.—In frequently-recurrent attacks of this affection—"always catching cold"—a condition generally dependent on impaired nerve-power and over-sensitive skin, the Turkish bath proves very useful; but when inadmissible for any reason, simple cold wet-towel friction in the morning should be substituted.

Tonsillitis—Diphtheria.—Thick compresses wrung out of cold water, applied to the throat and covered with flannel, usually give much relief, but sometimes answer better when soaked in very hot water (112° F.) and applied over the front part of the neck and chest, covered with flannel and oiled silk, and renewed every four to six hours.

Croup.—In true inflammatory croup, a very hot compress or sponge and steam-inhalation are especially to be recommended, and having been satisfied with these I have not often used the cold applications recommended by some authors.

In **Spasmodic Croup**, however, a cold wet cloth to the back of the neck and the larynx during the attack, and douching the spine or the whole body once or twice daily, is an effective treatment.

Thoracic Inflammations.—Niemeyer and other high authorities, chiefly German, have strongly advised continuous cold applications in the early stages of thoracic inflammation, both pleuritic and pneumonic, placing compresses over the affected side, and changing them frequently: they now even prefer the ice-bag in such cases. In English practice, however, this method

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is still regarded as involving unnecessary risk, and it has not been generally adopted.

Phthisis Pulmonalis.—The cold douche is used externally in phthisis, chiefly in Görbersdorf and Davos. It is only suitable for cases where the temperature of the body is normal, and the disease not actively progressing, and should be employed with the greatest care and under medical supervision. The patient at first is rubbed with dry towels, and then, on being made to take a deep inspiration, is exposed to the cold douche for five seconds—by degrees the duration of the douche may be prolonged, if desirable, to 45 or 60 seconds—immediately after, the body is dry-rubbed until the skin gets red and warm; the patient is then dressed, and active exercise, such as walking uphill, completes the process. Anæmic patients cannot bear the douche for more than five or ten seconds. When this treatment *can* be borne, it promotes appetite and digestion, and renders the patient less susceptible to the injurious influences of a changeable climate.

Fevers.—The application of water to the treatment of these disorders is one of the most important results of modern therapeutics—or rather of a revival of, and improvement upon, older ideas, for it is not wholly modern. Wright and Currie adopted it in 1786–1796, using cold affusion, *i.e.*, dashing several buckets of water over the patient when stripped. The latter physician records an epidemic of typhus fever affecting 58 soldiers, most of them severely: 56 were treated by cold salt-water affusion, and all recovered; the other 2, considered too weak for this treatment, were the only fatal cases. He traced an evening exacerbation, and insisted on the importance of using the remedy during this access: or at least during a period of great heat, and not during a rigor, nor during a profuse perspiration (Medical Reports on the Effects of Water, London, 1798). His method of treatment, although valuable and successful, was too harsh for ordinary use; but soon after his observations Giannini, of Milan, advocated immersion in cold water for two to fifteen minutes in all forms of fever (especially intermittent, petechial, rheumatic, and scarlet fevers): he drew up very judicious rules for practice, and he had very good success, but he objected to the use of ice (Della natura delle febbri, Milano, 1805). Fröhlich (1822) was one of the first

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to regulate his practice of cold or tepid bathing by the thermometer. An account of his and many other earlier observations has been given by Fleury (Traité d'Hydrothérapie, Paris, 1866). In our own time, Ziemssen has improved upon the older methods, by his process of gently lowering the patient (with a sheet) into a bath at a temperature of about 98° F., and then gradually cooling it by addition of cold water or ice to 80° or 72° F., or even lower, according to the effect produced: this should be noted by a thermometer (placed in the rectum if possible). When a distinct reduction of the fever heat is evident (it may be in five minutes or in thirty), the patient is dried, and laid again in bed, and the process may be repeated two to six times daily. A less complete mode of attaining a similar result is by cold compresses to the trunk, ice-bags to the spine and other parts, injections of iced water into the rectum, or the wet-sheet pack. All such applications, valuable as they are, must be carefully watched: they depress the circulation, sometimes extremely, and may need, after their use, stimulants internally, and hot cloths and bottles externally, in order to relieve too-cold extremities, blue lips, and tendency to collapse. The bath generally used in Germany has a temperature of about 70° F., or somewhat lower, and the patient is kept in it for about ten minutes, but very weak subjects only from five to seven minutes. Ziemssen now uses this bath, I believe, more frequently than the *gradually* cooled one, mostly mentioned with his name.

Hyper-pyrexia.—According to general, though not universal experience, a rise of temperature above 108° F. is quickly fatal, and a range between 105° and 112°, which may occur in acute rheumatism, etc., has been specially termed "hyper-pyrexia." Under the systematic use of cold applications, some remarkable recoveries from this critical condition have taken place, and two cases fully reported by Dr. Wilson Fox attracted much professional attention to the subject. They were both cases of rheumatic fever with cardiac complications: one, a woman of forty-nine, was lowered at 9·50 p.m. into a bath at 96°, when her temperature was 109·1° F. She was unconscious, the pulse imperceptible, the face cyanotic, the respiration irregular and gasping. At 9·55 p.m., the rectal temperature was 110°. "Ice was fetched, a large lump was placed on her chest, another on her abdomen, a

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bag filled with ice was tied down the length of the spine, and while two assistants baled the warmer water out of the bath, two others poured ice-water, as rapidly as the pails could be filled, over the patient." At 10·10 p.m., temperature was 109·1°: at 10·25 p.m. it was 106°; the pulse now became perceptible (140), and the patient showed signs of consciousness. Brandy was freely given. At 10·35 p.m. the temperature was 103·6° F., and the patient was taken out of the bath. At 10·55 the temperature was 100·6° F., lividity had disappeared, the patient could speak, and had a certain imperfect consciousness: the temperature continued to fall, till at 11·25 p.m. it was at 97·4° (vagina), and hot applications and an enema of brandy were required to prevent collapse. Another bath was given next day, when the body-temperature had risen to 104·5° F.; the bath was at 64° F., and was continued for twenty minutes; on removal, the patient's temperature was 103·9°, and it continued to fall for forty minutes longer till it reached 99·4°. Rigors occurred, and hot applications were again required. From this time, the cold treatment was continued by ice-bags to the spine, which sometimes were effective in reducing the body-heat, and sometimes not, but within a week from the baths, the patient was sitting up convalescent, and within a month was able to travel.

The second case presented more difficulties, and required a longer treatment: it occurred in a man, aged thirty-six, suffering from double pneumonia, double pleuritis, and pericardial effusion. On the seventeenth day of his disease, the temperature rising rapidly to 107° F., and delirium setting in, he was placed in a bath at 89° F., which was cooled to 86°. The after-effect of this was a fall of body-temperature to 98°, and return of consciousness. For eight days cold applications were kept up almost continuously; eight baths were given, of duration varying from twenty-five minutes to seventy minutes, and in the intervals, the ice-bag or wet-pack was used, the object being to keep the temperature under 103° F. at least. This patient also made a good recovery, but the temperature did not remain normal until thirty-one days after this treatment was commenced (Lancet, ii., 1871).

Shortly before these cases, Dr. Meding, treating rheumatic hyper-pyrexia in a female, aged twenty-two, with enemata

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of iced water every half-hour, and the application of iced cold cloths, reduced the temperature in five hours from 108·6° to 99·5° F., and the pulse from 140 to 72; no further rise ensued, and no relapse.

Of course, all cases have not been so successful, and Dr. Fox refers to several that ended badly; yet those quoted are sufficient to show the immense power of this mode of treatment, and it has, since that time, been fully endorsed by many English authorities. Dr. Anstie especially pressed its adoption, and Dr. Waters (Liverpool) has recently given good illustrations of its value in two cases of rheumatic fever, one with pericarditis, and both reaching a temperature of 106·7° F., and treated by baths at 95° to 100°, cooled to 70°, and sometimes lower (B. M. J., i., 1878). In a careful paper, Dr. Ord has given details of the use of graduated cold baths in ten cases of hyper-pyrexia, of which two were fatal (one of these had only one bath, and died eleven days afterwards of lung-congestion). In several of the cases, relief to nerve-excitement, and even to bronchial and congestive lung-condition, as well as to pyrexia, was marked; six was the largest number of baths given in any one case. The only contra-indication is excessive weakness. Dr. Ord advocates the systematic early use of this treatment, but also points out the difficulties in thoroughly carrying it out (St. Thomas's Hosp. Rep., 1879).

Acute Rheumatism.—I have often given the greatest relief in an ordinary but severe attack, with pain in all joints, sweating, pyrexia, etc., by means of a hot blanket-pack, the patient being enveloped in one blanket wrung out of hot water, and then covered with several others, and left thus for half an hour or more. Dr. Dowse has made scientific observations on this form of bath, and reported much benefit from it (B. M. J., i., 1875). In the blanket-pack he found temperature rise one to two degrees, and at the same time much sweating produced. He continued it for six hours at first, afterwards for one or two hours only; brandy was sometimes required for depression. He did not use this bath when the body-temperature was over 104° F., or the patient very prostrate, nor when the aortic valves were incompetent. In *chronic* gout and rheumatism the Turkish bath is especially useful.

Puerperal Fever.—In a very striking case reported by Dr.

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W. S. Playfair, a sheet or towels wrung from iced water were almost constantly applied for eleven days, the patient lying on a water-bed kept cold with running water, and having an ice-cap on the head. By these means only could the temperature be kept under 105°. Eventually the patient was saved, Warburg's tincture having some share in the result (B. M. J., ii., 1877). Dr. Wiltshire has also reported cases of this disease treated by *dry* cold, *i.e.*, ice packed in bottles and tins near the patient, with temporary good result under unfavourable conditions. Mr. Knowsley Thornton has found an ice-cap, for application to the head only, very useful in keeping down the temperature after ovariotomy.

Typhoid Fever.—Liebermeister, at Basle, systematized the treatment of typhoid fever by cold baths, and his records show a lowering of mortality from 26 per cent. to 7 per cent. So soon as the disease was declared, usually about the ninth day, the treatment was commenced with a bath at 68° F. for ten minutes; this was repeated, not at a fixed time, but so often as the temperature (taken every two or three hours) rose above 102° F. Sometimes six or seven baths were given in twenty-four hours, but commonly a less number. When they acted best an early remission of pyrexia occurred, and lasted for a long period. Quinine in full doses, or digitalis, were often combined with this treatment. Surgensen followed similar practice, and also Bartels, who claimed to reduce his mortality to 3 per cent. There can be no doubt that excellent results may be shown by these physicians, yet the risk of movement and disturbance in cases with serious intestinal lesion must not be ignored, and in the majority of instances other treatment will answer every indication.

Remittent Fever.—A similar method of systematic bathing has been followed with advantage in the remittent fever of the tropics, and Dr. Lucas has recently described a severe case in which the patient (at 103° F.) was lowered into a bath at 80°, and a small continuous stream of cold water was poured over the body for eight minutes. After return to bed the temperature was 97°; quinine and port wine were given. After seven days of bathing—the temperature being kept under 103°—some bronchitis having developed, injections of cold water into the rectum

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were substituted for the bath, and with very definite effect in lowering temperature; recovery occurred in about a month (Med. Times, ii., 1879). In intermittent fever, both Currie and Giannini used cold affusion and bathing with excellent effect, and found that it prevented or delayed a paroxysm if given an hour before its usual access; also that the water-treatment much assisted the action of quinine. Dr. Fleury, however, claims for his cold douche much more than this, stating that he has radically cured by it more than 100 cases of all forms of intermittent fever, many of them rebellious to all ordinary treatment (including quinine, arsenic, change of climate, etc.), and he quotes evidence on the subject which should receive earnest attention. An energetic cold douche for fifteen or twenty seconds can relieve both the pyretic and the congestive, and also the anæmic condition. For preventing a paroxysm it should be used a quarter of an hour before the expected onset; if this come on before its time, the douche may even be used in the cold stage with good effect, if given strongly for a short time so as to be excitant; if necessary, a second may be given in the hot stage. In irregular intermittents the abdominal viscera are usually congested, and Fleury finds the douche competent to reduce both liver and spleen to their normal size in comparatively short time. Cerebral complications require compresses; pulmonary œdema and acute bronchitis contra-indicate the treatment. In bilious subjects purgatives may be required, or other treatment conjoined.

Scarlatina.—In this fever, some of the very best results of cold bathing and packing have been obtained. In mild cases, tepid or cold sponging during the course of the disorder, and a few carbolized warm baths at the termination are all that is necessary. The warm baths during the period of desquamation help the process, and give much comfort to the patient, especially if followed by inunction of carbolized oil or glycerine. They also stimulate the action of the skin, and lessen renal congestion, or the risk of it, and also the chance of infecting other persons.

Dr. Vaudrey Lush, indeed, and some other physicians, have advocated the routine use of the warm bath from three to five minutes at first three times a day, afterwards less often, for every case of the malady (Lancet, ii., 1880); but without denying

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the advantages of this method, it is clearly often impracticable, and cannot be considered necessary.

In very severe cases, however, when the temperature rises to 104°, 105°, or 106° F., and there is delirium or stupor, the rash being dark and indistinct, and the urine scanty and albuminous, I have frequently seen, even in apparently hopeless conditions, the cold or hot wet pack bring out a vivid rash, and cause lowering of temperature and abatement of all severe symptoms.[1] Dr. Edison has reported two illustrations of this, occurring in children, with delirium, etc., and both successfully treated by frequent bathing (Lancet, 1877); interesting cases treated by cold affusion, also valuable cautions on the subject may be found in Trousseau's Clinical Lectures (vol. ii.).

I first used the *hot* pack in a case of suppressed scarlatina (where the prejudices of parents prevented the usual cold applications), and finding the results equally good, I have commonly adopted it. In the case of a boy whom I found convulsed, and with dusky purplish skin, on the third day of what was presumed to be scarlatina, the hot sheet acted admirably. The throat was much affected, albumen was in the urine, and consciousness was lost. Within half an hour of commencing the hot pack he was able to speak, perspired freely, and the rash came out a vivid red; he was afterwards put in blankets, and went on perfectly well without the necessity of repeating the pack. In another still more severe case, the convulsions had lasted over two days, the child was quite blue, there was albumen in the urine, and his life was despaired of; but in the first pack consciousness returned, and recovery followed.

The vapour-bath is another mode of effecting the same results, and is especially applicable when renal congestion and albuminuria are marked, and in such cases compresses, poultices, or fomentations should be kept applied over the loins. The instances given will suffice to show the power of this treatment, although certainly there are cases of malignant scarlet fever which no art can save.

[1] Although, as above stated, temperature is commonly reduced in the pack, I have known it rise 2° to 3° F. in five different patients in the cold pack, and in four others in the hot pack. At one time I thought such an occurrence to contra-indicate the treatment, but further experience has shown me that it does not do so, and I believe that even in the nine cases referred to, recovery was assisted by the treatment.

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For the *sore throat* of scarlatina, compresses should be used externally. I find it best to have the throat bathed with water as hot as can be borne, for about five minutes every three or four hours, and directly afterwards a bandage, wrung out of water at about 112° F., should be applied round the neck and covered with oiled silk. This should be continued for three or four days as an adjunct to other treatment. Dr. H. Corson (U.S.) recommends a piece of ice, in gutta-percha, over each parotid gland. Warm water is a good gargle, or ice may be swallowed in small pieces with much advantage.

In Measles, Small-pox, and other eruptive disorders, similar treatment by bathing and packing is valuable.

Nephritis.—In acute nephritis from other than scarlatinal causes, warm packing and vapour-baths, and similar means of inducing diaphoresis, are almost equally valuable for relieving the renal congestion and eliminating waste products. In chronic nephritis they act especially as eliminants, and they also lessen dropsy.

Hepatic Congestion.—In acute cases, hot packing over the liver, and in subacute and chronic cases hot mustard-packing and a course of Turkish baths, are highly serviceable.

Catarrhal Jaundice.—Krull has written to advocate the treatment of this malady by the slow injection into the bowel of 30 to 70 oz. of water at a temperature of 60° to 72°. This may be practised for as long a time, and to the extent that the patient can bear it, once in the day: seldom more than seven "irrigations" are required. They are said to relieve gastric troubles, to improve appetite, and quickly cause the reappearance of bile in the stools. The increased intestinal peristalsis is presumed to induce corresponding contraction in the biliary passages.

Typhlitis—Peritonitis.—The application of an ice-bag, or of iced compresses, in these conditions has often proved more useful than the usual orthodox poultice, and in early stages, the local inflammation and the general pyrexial state may both be relieved by local cold. On the other hand, in some cases a prolonged hot sitz-bath, or smoking-hot fomentations, renewed about every half-hour, give great relief. The nausea or vomiting is often quickly checked by administer-

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ing small quantities of ice or iced water; at other times by hot water.

Diarrhœa.—The abdominal pain of acute diarrhœa is soothed by compresses, poultices, or warm bathing. In children some care is required as to the bath, for convulsions have occurred on placing a child suffering from diarrhœa in a bath at 98° F. This was most likely from an increase in body-temperature under the influence of external heat (Dr. Haddon, Practitioner, vol. viii.). The child ultimately recovered, but in such a case the cold sheet would probably answer better.

Cold applications are often more suitable than hot ones in choleraic diarrhœa (McKenna, Lancet, ii., 1876), and I agree with Messemer in the experience that cold water enemata act excellently as tonics and astringents in chronic cases. If slowly injected, they distend and keep apart the coats of the bowel, and thus save irritation (Med. Record, 1878): I have followed this practice for many years. Wenzel, an experienced naval surgeon, recommends injections of ice-cold water in dysentery, and has found recent acute cases subside quickly under this without other treatment. Fleury gives some remarkable illustrations of chronic dysentery and diarrhœa cured by the systematic use of the cold douche, one patient, aged forty, having previously used many medicinal remedies under able physicians. It is certainly a remedy to be remembered in obsinate cases.

Even in cholera the application of water, warm or cold, may be made highly serviceable. Trousseau wrote strongly in its favour when prejudice against it was greater than it is at present. The stage of collapse may be controlled by a *hot* mustard blanket-pack; but, as a rule, more permanent good will be obtained from *cold* applications. Niemeyer is an authority for recommending the pack with iced sheets in cholera (Lancet, ii., 1876, p. 346), and Dr. Chapman has offered evidence in favour of ice-bags to the spine.

Skin-Diseases.—In all forms of dry, scaly, skin-disease (whether syphilitic or not) warm baths (especially when made emollient and alkaline) and vapour-baths are useful. In acne, hot bathing or steaming opens up the glands and relieves congestion. In psoriasis, ichthyosis, lichen, prurigo, "pityriasis rubra," and chronic dry eczema and seborrhœa, for removing

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accumulated secretion or preventing contact of air, water compresses are serviceable. Hebra has tried the prolonged warm bath for from *two hours* to *nine months* at a time, in some such cases, and in extensive burns, etc., and has ascertained that nutrition, respiration, and secretion go on in the continued bath in a normal manner (Med. Record, 1877). On the other hand, in some skins, and especially when the epidermis is removed, as it commonly is in acute eczema, water is apt to excite much irritation.

Cerebral Congestion.—Cold applied to the head, whilst hot mustard-water is used to the feet, is one of the simplest modes of equalizing the cerebral circulation. It must, however, be used with caution where cerebral anæmia is readily induced, as in weakly subjects. Ice to the nape of the neck also acts well, and sometimes the *alternate* use of cold and hot applications gives the best results. This is especially the case in the congestion of opium-narcosis, uræmia, and carbonic acid poisoning (Bartholow).

Meningitis.—In cerebral or spinal meningitis the application of ice is a valuable resource, but if the face be pale, and there be tendency to chilliness and prostration, it is not suitable.

Sunstroke—"Thermic Fever."—When the head is hot, the pupils contracted, the pulse full, and the temperature high, cold packing is decidedly indicated, also cold affusions, especially to the head.

Delirium Tremens.—When the symptoms are violent and acute, with flushing and heat of head, full pulse, and much restlessness, a cold pack, or, if possible, a douche, or at least an ice-bag or cold compresses to the head, may be very useful in procuring quiet, and even sleep. When much depression or evidence of vascular degeneration exists, such treatment must be employed with extra care.

Insomnia.—This is often dependent upon functional congestion of the nerve-centres, and is amenable to different applications of water. The general tepid bath is suitable for children especially. A cold sitz bath relieves after intellectual work, or even a cold compress of a folded wet towel placed on the epigastrium, and covered by a dry towel, is often very

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efficacious. A hot mustard foot-bath, whilst cold is applied to the head, or a rapid dipping of the feet in cold water and vigorous friction afterwards, tend to the same result.

Mental Disorder — Melancholia. — So valuable is the douche-bath in some mental cases that there has been a tendency to overdo this form of treatment, and even fatal results have been recorded from it in cases of extreme depression. It is important not to use it too long at a time. Ten to twenty seconds is sufficient for melancholic cases, and the patient should stand in warm water, so as to secure warmth of the extremities. One or two minutes of a shower-bath should suffice for excited cases, and often a prolonged warm bath (thirty minutes), whilst cold is applied to the head, is the most soothing form of treatment. The Turkish bath has recently been introduced into asylums, and with some excellent results.

Hypochondriasis.—A course of cold water treatment, which is at first stimulating and afterwards soothing, is useful in this affection. It generally stimulates the vital functions, promotes tissue-change and nutrition, invigorates the skin, and strengthens the physical and mental condition. Other kinds of treatment, however, are often more successful.

Impotence.—When this arises from excess, cold sitz baths and spinal washings often relieve.

Convulsion.—The reflex convulsions of infancy are often cut short by a warm bath, cold water being poured on the head at the same time (*v.* p. 188). Hysterical convulsion is sometimes arrested by a sudden shock of cold to the surface, and a daily shower-bath is of great service in improving the hysterical state.

In **Chorea** cold affusion, especially over the spine, is very beneficial.

In **Uræmic Convulsion**, this treatment is not so markedly effective, though cold to the head is advisable; but the use of packing, or of the vapour-bath, so soon as the general condition admits, is often of the greatest service.

Tetanus.—Currie, Giannini, and other early observers record benefit from cold applications in tetanus, and illustrations of it have been published by Dr. W. S. Playfair in his Indian

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experience (Med. Times, i., 1862). Of three severe cases of acute tetanus, two were markedly relieved by the application of ice in bladders along the spine; the third was considered too weak for a treatment which is in itself depressant, and this one only ended fatally.

Hydrophobia.—Free action of the skin offers one of the best hopes in this disease, and may be secured by means of the Turkish or vapour-bath. Buisson, a French physician, has recorded that, having become inoculated with the poison of rabies, and feeling the access of the malady, he went into a hot vapour-bath (107° F.) with the intention of committing suicide, but found his symptoms shortly relieved, and by a course of such baths (127° to 140° F.) quite cured. He adds that he has treated many similar cases successfully (Lancet, ii., 1877). In a case of Mr. Southam's, which occurred recently at the Manchester Infirmary, a girl was very much relieved of severe symptoms whilst in a "lamp-bath" and perspiring freely, though a sudden spasm of the larynx caused her death some hours afterwards (Med. Record, Oct., 1879).

Paraplegia.—In cases connected with functional disorder of the cord, hot, or alternate hot and cold douches to the spine often act very well. Paralysed limbs that have become cold and wasted may often be much improved by towel-packing and douches, combined with vigorous friction.

Spinal Pain.—The sense of weakness and exhaustion referred especially to the lower part of the spine, occurring in delicate subjects after over-exertion of any kind, and due probably to a passive congestion, is much relieved by cold "spinal washings," or gentle douching each day for a short time, and followed by good friction. Dr. Moxon has recently drawn attention to the comparatively feeble circulation in the lower part of the cord, and doubtless such remedies act by quickening and regulating the blood-current in that part (Croonian Lectures, B. M. J., i., 1881).

The more acute backache, commonly felt by women, and in the absence of definite cause traceable often to "anæmia of the cord" (Bartholow), is better relieved by hot applications; and if the douche be not obtainable, then a hot sponge or fomentation will serve.

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THERAPEUTICAL ACTION.—*Internal.*—Preissnitz and his early followers combined with the outward application of cold water its immoderate and excessive use internally, an error which led to some evil result, and which is not often now repeated. Water-drinking is now ordered on general dietetic principles rather than as an essential part of a hydropathic course (Braun, chap. v.). In chronic illness good results are more rapidly and easily obtained by the use of *mineral waters* in moderate quantities, and containing salts and gas, so that the number of illnesses in which ordinary water is internally employed as a remedy is not large. Its most common internal use, medicinally, is as a solvent and diluent.

In **Fevers** of all kinds it is used to lessen thirst, to lower temperature, and restore the balance of fluid constituents of the tissues; also to promote secretion and the elimination of waste products.

Nephritis.—A copious supply of pure water is an effective, non-irritant diuretic, and is very useful in acute renal congestion and inflammation, washing out epithelium and casts from the obstructed tubules. It renders more soluble, also, and helps to carry off, all the products of retrograde metamorphosis, and the good effect of many infusions and decoctions is doubtless largely due to the amount of water they contain.

Constipation.—A glass of cold water taken, fasting, in the early morning, will assist in securing a regular action of the bowels. If taken, also, the last thing at night, it has a still better effect. Cold hip-baths are useful for the same purpose.

Hæmorrhoids.—Plentiful water-drinking is indicated in this disorder as a means of relieving the liver by securing a greater flow of bile and accelerating elimination, but a course of aperient *mineral* waters is more effective.

Chronic Metallic Poisoning.—In some cases of this kind, the taking of a large quantity of water is useful by aiding solution of minerals deposited in the tissues, *e.g.*, antimony, arsenic, lead, copper, mercury, etc., or rather their mechanical removal by disintegration of cells. If, however, anæmia be marked, as it often is, this method must be used with care, for fear of impairing nutrition.

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Syphilis.—In the later stages of syphilis, or when relapses are frequent, and mercury or iodides are not well borne, hydropathic treatment is a useful resource, tissue-change being promoted by the wet sheet and free water-drinking. Good results are also derived in this disease from the eliminant influence of the Turkish bath, and the occasional use of this during a mercurial course is always advisable.

Gout—Gravel.—In these cases, hydrotherapy can improve the general condition, and sometimes, it is said, disperse concretions. It promotes lixiviation and increased change of substance, as shown by increase of urea, and renders uric acid soluble. It will not, however, produce the marvellous cures sometimes expected of it.

The dietetic use of *hot water* in gout has been recommended, one or two tumblerfuls of water at 120° being given in the early morning. This is said to regulate the bowels, to cause the disappearance of lithic acid and lithate sediments, and diminish the frequency of acute attacks (Weber). Cadet de Vaux (1825) carried this idea to an extravagant pitch, ordering 8 oz. of hot water (120° to 140° F.) every quarter-hour for twelve hours. Some patients bore this, but others suffered from vomiting, excitement, congestion of the brain, or fever.

The *formation of gravel* is caused, according to Scherer, not by excessive secretion of acid, but by the fermentation of the urine itself, yet the diminution of the secretion of acid must produce a favourable effect; and also the dilution of the urine renders it less irritating to the mucous membrane, and washes away from the membrane, mucus which would produce fermentation. Hence plain water-drinking is good in this condition (Braun), though preference is now commonly given to mineral waters.

SEA-BATHING.

In sea-water the more important saline constituents are the chlorides of sodium and magnesium, and the sulphate and carbonate of lime. Iodides and bromides are contained in minute quantity. Hence the effect of sea-bathing upon the skin and its peripheral nerves is more *stimulating* than that of ordinary

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water, an effect which is much heightened by the stroke of the waves (Wellenschlag).

The incoming wave beats more upon the upper part of the person, the receding wave upon the lower extremities, providing one of the best forms of douche-bath for such as are strong enough to bear it.

This wave-stroke is naturally more effective in some seas and on some coasts than on others. In the German Ocean (east coast of England) and in the Atlantic (south coast) it is much stronger than in the Baltic or the Mediterranean, and bathing at Cannes, for instance, is not to be compared in bracing effect with bathing at Brighton.

The temperature of the water is an important point in estimating the effect of any form of bath. The temperature of the sea varies less throughout the year than that of rivers: it is highest in the Mediterranean (72° to 80° F.), lowest in the Baltic (60° to 62° F.), and intermediate in the Atlantic (68° to 73° F.). It is higher in autumn than in summer, and hence, September is a good month for sea-bathing, though the wave-stroke is not then so forcible as it is earlier. The temperature of the water is often as much as 12° F. higher than that of the air, and at midday it is several degrees higher than in the early morning.

In considering the influence of sea-water, that of *sea-air* must not be wholly omitted. It contains more ozone, more moisture, and more salt than country air, with less carbonic acid, and usually less dust and foreign admixture; in fine weather the air is more clear and the sun-light more powerful at the coast than inland, and the current of the air is usually stronger and more bracing.

PHYSIOLOGICAL ACTION.—On entering the water, under ordinary conditions, a sense of cold is felt; the skin becomes pale and roughened (goose-flesh), the circulation depressed, and the respiration more or less spasmodic; but in suitable subjects this temporary depression is quickly followed by reaction—the skin reddens, the pulse rises and becomes more forcible, whilst exhilaration and a sense of increased vigour indicate the stimulation of the nervous system. If the bather avoid overtaxing his

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powers, and will leave the bath before this period of stimulation is passed, he will probably retain, for several hours, a feeling of improved health and general well-being, and it is to such cases that the following statement of physiological results will apply.

Tissue-change is promoted, as shown by an increased excretion of urea and sulphuric acid (Beneke); not that these are immediately or inordinately increased, but the natural healthy maximum is kept up for a much longer time than usual (Ringer). Appetite and digestion are certainly promoted; but if only such a measured amount of food be taken as suffices to maintain the body-weight at a fixed point under ordinary circumstances, *loss* of weight is experienced owing to the increased tissue-change, while if the quantity of food be *increased in proportion to* the improved appetite and digestion, the body-weight is decidedly *increased* by a course of sea-bathing.

The skin-secretion, though at first checked, is afterwards promoted: the effect of the first contraction of the skin capillaries is sometimes, if the water be very cold, to determine blood to internal organs, and hence some congestion of the kidneys may occur, and a trace of albumen may be found in the urine; but this condition soon passes off, and the albumen does not persist after the bath.

The urinary water is increased at the time, though it is said that the day's *total* is rather less than normal. The intestinal excretion is usually lessened, but sometimes increased (Beneke), and either constipation or diarrhœa may be induced.

Restlessness and sleeplessness are more serious symptoms occasionally caused, but in my experience as much by a residence on the *sea-level* as by simple bathing. The hot, strongly saline baths, as at Droitwich, do, however, often induce an extreme degree of restlessness, and should not be used too frequently.

It is worth noting that the long hair of women, when often soaked with salt-water, may fall off, but it quickly grows again.

THERAPEUTICAL ACTION.—Sea-bathing tends to "harden the skin," to moderate undue perspiration, and to diminish

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the tendency to catching cold and to rheumatic attacks. It acts as a general stimulant in all conditions of constitutional debility, and also as a local stimulant, promoting absorption and improving circulation.

In **Chronic Forms of Nerve-Disorder** with depression, and hypochondriasis, sea-bathing is often very beneficial through a strongly stimulant action on the peripheral cutaneous nerves: by its influence on tissue-change it is said to benefit, not only in functional disorder, but even after material change in the nerve-substance (Husemann).

Struma, etc.—In various forms of struma, scrofula, and chronic conditions of blood-poisoning, sea-baths are indicated, and during convalescence from fevers and other acute disorders, or after prolonged town-residence or town-work, they have an excellent effect.

Sprains, etc.—As a remedy for the effects of *sprain* or of *injury to joints*, or of *spinal weakness*, douches of hot and cold sea-water are exceedingly useful.

Recently gargles of the same are said to have proved curative in chronic relaxed conditions of throat, "Clergyman's Sore Throat," etc. (B. M. J., July, 1879).

TIME OF BATHING.—To bathe before breakfast is the custom of some robust persons, but is never free from risk, and sometimes seriously injures weakly subjects: for after the long fast of night the circulatory and central nervous organs are more liable to depression from sudden shock or over-fatigue. On the other hand, to bathe soon after a meal arrests the process of digestion, and may give rise to very unpleasant gastric and cerebral symptoms. The best results are obtained from bathing two or three hours after the early morning meal, when the stomach is nearly empty, and there should be at least a brief interval of rest or of but moderate exercise, according to the weather, between the bath and the following meal. The object aimed at being a marked and prolonged reaction, this is best obtained from a bath taken during a condition of the greatest nutritive and functional activity, when the work of the stomach is over and the blood is enriched by the products of digestion.

ERRORS IN BATHING.—The good effects already described as proper to sea-bathing may be missed, and very

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unpleasant symptoms may arise, if attention be not given to certain points.

The therapeutical object is to secure and sustain a good *reaction*, and this is impaired if the bath be too cold, or too prolonged, or if excessive exertion be taken before, during, or after it, or if the patient be under the influence of strong emotion, as a nervous, frightened child would be. The most common errors are to prolong the bath unduly and to exert oneself overmuch during it: the sense of vigour is then replaced by exhaustion, the skin again becomes cold, and the circulation depressed; giddiness and headache occur from altered conditions of the circulation, with general malaise, and possibly shivering, nausea, sickness, and a sense of depression lasting for many hours. It is therefore important to leave the bath before the stage of reaction and stimulation is finished. With some persons the stroke of three or four good waves is sufficient for the best results, five minutes is an average time for the delicate to remain in the water, and no one bathing for *health only* should remain in the open sea for more than ten minutes.

CONTRA-INDICATIONS. — At the extremes of life, sea-bathing in the open should be practised cautiously. As a rule, it is unsuited for children under two years of age, or for patients over sixty. Pregnancy in healthy subjects need not prevent the use of salt baths, or sea-bathing, provided that the patient is accustomed to a cold bath previously, but, as a rule, the various inconveniences of open-air bathing render its risks greater than any advantage in that state. The tendency to cause congestion, more or less temporary, of internal organs, the brain, liver, lung, or kidney, renders open-air sea-bathing unsuitable for persons disposed to such disorders, or suffering from structural change or marked blood-stasis within the abdominal organs, albuminuria, serious cardiac disease, chronic pneumonic infiltrations, hæmoptysis, fatty degeneration, or rheumatism which is at all acute. An extreme degree of anæmia is a contra-indication.

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MINERAL WATERS AND BATHS.

The so-called *mineral* waters are really medicines, largely diluted and complex, containing various salts and gases derived from the soils through which they pass, and administered at varying temperatures, generally warm.

PHYSIOLOGICAL ACTION.—Applied *externally* in the various forms of bath, they act like the plain water baths already described, with special powers of stimulating the skin, and indirectly the visceral circulation, or of quickening absorption and lessening pain.

Given *internally*, they act by promoting tissue-change, secretion, and excretion, thus diluting and depurating the blood, and increasing the bile and other organic liquids. "Critical eruptions and discharges may occur during their administration, but are not advantageous."

Their action is not to be explained solely by the proportion of ingredients recognized by an analysis—*e.g.*, 1½ dr. of magnesia sulphate has far more purgative effect when taken in the form of a natural water than when dispensed by a chemist, and hence, although imitated, they cannot be quite replaced by artificial combinations.

THERAPEUTICAL ACTION.—Mineral waters are mainly used in *chronic* functional disorders, and in conditions of debility and convalescence, but are suitable also for early stages of organic disease. In estimating their effects, allowance must be made for the change of climate and surroundings, and the more regular, simple, and quiet life of a Spa. Hence the drinking of imported waters at home will not give the same result as taking them at their source.

Season.—The usual season for drinking the mineral waters includes summer and autumn, *i.e.*, extends from May or June to September or October, and the duration of a course is from three to six weeks. Too prolonged continuance of the treatment is liable to do harm.

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DOSE AND MODE OF ADMINISTRATION.—It must be recognized that benefit is not derived in proportion to the quantity of water taken: at first only small quantities daily are desirable. Bathing and drinking should not be commenced on the same day. When the strength permits, early rising is advisable, so that the water may be taken before breakfast; it should be sipped slowly, and an interval allowed for a gentle walk between each glass. The diet should be carefully regulated—it is usually less generous abroad than in this country. As a rule, some physician resident at the Spa should be consulted.

CLASSIFICATION.

Braun, in his excellent treatise (edited by Dr. H. Weber, 1875), classifies "Mineral Waters" somewhat as follows:—

Class 1.—CARBONIC ACID WATERS comprise many of various character, more or less impregnated with this gas, which renders them easier of digestion, and *chemically* assists the solution of bicarbonates, *e.g.*, of soda and iron. Their *medicinal* properties are, to lessen gastric irritability, to stimulate slightly the secretions of the stomach and of the kidneys, and to increase the peristaltic action of the intestines.

There are a few springs which contain only a small amount of saline ingredient with so much *gas* that they may be called *simple acidulated or carbonated waters*, but none of these are active enough to be in demand beyond their own locality. All the commonly used aërated waters contain a notable proportion of alkalies, chlorides, earths, or iron, and hence, although containing carbonic acid, find their place rather in the following classes.

Class 2.—SALINE WATERS.

(*a*) **Simple Alkaline Waters** (containing carbonate of soda as a main ingredient), are such as those of Vichy and Neuenahr, Salzbrunn, Mont Dore, Bilin, Gieshübel, Apollinaris, etc.

(*b*) **Muriatic Soda Waters** contain in addition sufficient

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chloride of sodium to correct the dyspepsia or debility sometimes induced by a *pure* soda water, and are those of Luhatschowitz, Ems, La Bourboule, etc. (*v.* pp. 204, 205).

These and the preceding waters are ordered in cases of acid gravel, gout, venous stasis, and abdominal obstruction, in scrofulous exudations, in diabetes, and in chronic catarrh of the respiratory, gastric, or genito-urinary tract. In catarrh especially, waters containing chloride are to be preferred.

(*c*) **Bitter Waters** ("purging saline waters") containing sulphate of soda and magnesia as chief ingredients are such as Friedrichshall, Hunyadi Janos, Püllna, Seidlitz, Epsom, Beulah Spa, Purton, Cheltenham, Leamington, Scarborough (*v.* pp. 205—207).

One or two wineglassfuls of these waters (preferably taken warm) stimulate the gastro-intestinal mucous membrane, and produce a watery discharge from its glands. They are useful in habitual constipation, especially when this is connected with torpor or congestion of the liver; but if given too frequently, or in excessive dose, they are apt to bring on flatulence, dyspepsia, or intestinal catarrh in delicate subjects.

(*d*) **Compound Soda Waters** (containing sulphate of soda in effective doses) are Carlsbad, Marienbad, Franzensbad, Tarasp, etc. (*v.* pp. 207—210). These are ordered in gout, gravel, diabetes, and catarrh, like the simple soda waters, and also more especially in dyspepsia, corpulence, jaundice, gall-stones, and hyperæmic enlargement of the liver, and in hæmorrhoids occurring in plethoric persons. These waters, if freely used, are markedly lowering in their action.

(*e*) **Common-Salt Waters** include those of Homburg, Kissingen, Baden-Baden, Wiesbaden, Reichenhall, Kreuznach, Harrogate (*v.* pp. 210—216).

These waters are used, taken cold and in but moderate quantity, in dyspepsia and gastric catarrh; also in constipation and chronic intestinal catarrh; for early stages of abdominal plethora, and for hæmorrhoids and venous stasis occurring in thin depressed subjects; also in bone-disease and scrofulous exudations, inflammatory effusions, and glandular and even fibroid tumours.

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Class 3.—SULPHUR WATERS, which contain alkaline sulphides or sulphuretted hydrogen, are found at Aix-la-Chapelle and Aix-les-Bains, Weilbach, Barèges, Luchon, Cauterets, Harrogate, Llandrindrod, Moffat, Lisdoonvarna, etc. (*v.* pp. 216—222). They are used for chronic syphilitic and scrofulous disorders, bronchial catarrh and phthisis, chronic hepatic congestion, chronic rheumatism, and metallic poisoning, such as that from lead or mercury. The digestive powers are liable to be taxed by a course of these waters, and more or less anæmia is apt to follow. Good meat diet is desirable whilst sulphur is being taken.

Class 4.—EARTHY MINERAL WATERS (containing a large proportion of lime).—Rehme, Eilsen, Leuk, Weissenburg, Wildungen, etc., and many other waters, contain a small proportion of carbonates of lime and of magnesia (*v.* pp. 222—224). The special springs named are used in vesical catarrh and uric acid concretions, in gouty and scrofulous exudations and skin-diseases, also in bronchial catarrh and phthisis. Separate classes are made by some authors, *e.g.*, of the *iodo-bromated* waters at Kreuznach and Woodhall, and the *muriated lithia* waters of Baden-Baden.

Class 5.—THE "INDIFFERENT" WATERS of Leuk, Gastein, Wildbad, Schlangenbad, Buxton, etc., are used almost wholly in the form of *bath* in cases of rheumatism, paralysis, and other nervous disorders (*v.* pp. 224—227).

Class 6.—CHALYBEATE WATERS, those in which iron carbonate is the main ingredient, are such as Spa, Schwalbach, Tunbridge Wells, Driburg, Pyrmont, Harrogate. The sulphate occurs in springs at Brighton and at Sand Rock (Isle of Wight); the perchloride in a spring at Harrogate (Muspratt's).

These waters are used in chlorosis, direct anæmia, irregularities of menstruation, atonic conditions of the stomach and intestine, in general debility, and in various neuroses. Care is required to secure their due absorption without dyspepsia. The general rules for iron-medication are further indicated in the chapter on that remedy.

A knowledge of Spas and mineral waters is so necessary in modern practice that a more detailed, though necessarily brief, account of the principal ones is subjoined.

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CLASS 2 (a).—SIMPLE ALKALINE WATERS.

Vichy, in central France, 780 feet above the sea, is situated on the River Allier, in a large open valley surrounded by vine-clad hills; the climate is mild, the season is from the middle of May to mid-September. The arrangements are on a magnificent scale, and the Spa is the most frequented in Europe (Braun).

The springs used are nine in number, all clear, warm, and tasting more or less like soda water; they contain from 36 to 39 gr. of bicarbonate of soda in each pound (16 oz.), from 12 to 14 cub. in. of carbonic acid, and small quantities of chloride of sodium (4 gr.), of bicarbonate of potash, and of magnesia, and arseniate of soda.

They may be used in any case in which strong alkaline waters are indicated, and either for bathing or drinking, or both. The *Grande Grille*, which has a temperature of 113° F. is in most repute, especially for hepatic disorders, the *Celestins* for urinary maladies, and the *Hôpital* for abdominal stasis, chronic enteritis, etc. The *Hauterive* is cold, and contains an unusually large amount of carbonic acid.

The most suitable cases for Vichy are those of uric acid gravel and calculus, gout, vesical catarrh, and diabetes of the slow and less pronounced kind. But besides these, a large number of other maladies are treated there with more or less success—such as dyspepsia, gastric catarrh, enlargement of liver and spleen, abdominal congestions, chronic metritis, and chronic rheumatism. The dose of the water is from half a pint to two pints daily.

Vals, in the south-east of France (Department Ardèche), is an important Spa with cold alkaline springs, similar in composition to the waters of Vichy. The principal ones, *Précieuse*, *Désirée*, *Madeleine*, and *Rigolette*, contain rather more bicarbonate of soda and carbonic acid and iron. The two former, slightly laxative, are employed in gouty and renal disorders; the two latter are more roborant. *St. Jean* is less alkaline, and is ordered for dyspepsia; *Dominique* is arsenical. The waters of Vals and Vichy are largely exported.

Neuenahr, in Rhenish Prussia, 300 feet above the sea, in the mild and beautifully-wooded valley of the Ahr, is easily reached from Cologne. It has excellent buildings and public

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gardens, and is rising in estimation. It possesses a cold spring rich in carbonic acid, and four warm springs—93° to 104° F.—each containing about 9 gr. in the pound of bicarbonate of soda, with a small proportion of lime and magnesia, much carbonic acid, very little chloride of sodium or iron.

Bilin, in Bohemia, and **Fachingen**, in the valley of the **Lahn**, contain strong soda springs, which, however, are but little used on the spot, though they are exported in large quantities. The water of Bilin contains 33 gr. of bicarbonate in the pound, with chloride 2 gr., and sulphate 6 gr., lime 4 gr., a trace of iron, and much carbonic acid, at a temperature of 53° F., and generally requires to be heated. That of Fachingen is very similar, but somewhat weaker. Both are used for severe cases of gravel, gout, and vesical catarrh.

The water of **Gieshübel**, near Carlsbad, contains a small proportion (10 gr. to the pound) of bicarbonate of soda, with a large amount (55 cub. in. to the pound) of carbonic acid. It is pleasant and refreshing, and exerts a moderate antacid effect.

Apollinaris water, from a spring of that name, situated near Neuenahr, in the valley of the Ahr, contains about 10 gr. of bicarbonate of soda, 3 gr. of chloride, 2 gr. of sulphate, and 3 gr. of magnesian carbonate, with a large amount of carbonic acid to the pound, so that it may be warmed without losing its pungency.

It is useful as a table water in irritable conditions of the stomach, and as a medicinal water in the lithic acid diathesis and gout; also in bronchial catarrh and tendency to gall-stone.

Salzbrunn, in Silesia, near Freiburg, situated in a wooded valley 1,200 feet above the sea, has a fresh bracing climate, and has soda waters with about 18 gr. of bicarbonate in the pound (16 oz.). It has been called "the cold Ems," and has been especially recommended in bronchial catarrh and in early stages of consumption when Ems is not suitable. A much frequented establishment for the "whey-cure" and "moor-baths" is also to be found at Salzbrunn.

Mont Dore lies in a charming valley of the Auvergne Mountains, 3,300 feet above the sea, and possesses a cold and several warm soda springs (106° to 108° F.). They contain only

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about 5 gr. of bicarbonate to the pound, but more chloride of sodium than those yet mentioned, also an excess of carbonic acid. The *Madeleine* is also arsenical. The Spa is well provided with appliances for separate baths, douches, sprays, and inhalations, and has a reputation in chronic pulmonary catarrh and asthma, and in chronic hepatic congestion and rheumatism. "Most invalids employ warm bathing, the effect of which is to increase perspiration, and after some days to induce a 'bath fever,' with lassitude, constipation, etc., but this soon passes off." It has a reputation for benefiting and often curing emaciated broken-winded *horses* with bad coughs. It has been recently proposed to introduce all the resources of Mont Dore into an English establishment at Bournemouth.

CLASS 2 (b).—MURIATIC SODA WATERS.

Ems, near Coblenz, in the valley of the Lahn, 291 feet above the sea, is the oldest and most famous soda spring. It is conveniently reached from England, has excellent hotels, and English-speaking physicians. The valley is narrow, between high mountains, with attractive scenery, and possessing a mild climate. "There are few bathing resorts where a sick person may find in intercourse with nature and man, and in the enjoyment of a brilliant but unpretending Spa-life, such rich opportunity both for coming out of himself, and for self-reflection. Ems is the pearl of Germany" (Braun). Cases of phthisis, however, should not be sent there, as by day the air is hot and still, and in the early autumn, mists at night and morning are frequent. The best months are May and June, September and October. During July and August, when many English people go, the climate is likely to be found oppressive and relaxing. The mineral springs contain a medium amount of bicarbonate of soda (10 gr.), and of carbonic acid (19 cub. in.), and of chloride (7 gr.), with very small amounts of lime and magnesia.[1] The main difference between the springs is in temperature, the *Kranchen* being at 84° F., and the *Kessel* at 114° F. They are often given with goats' or asses' milk, and are used for chronic bronchial disorders with irritable

[1] In this and all the following analyses the quantities are calculated for a pound of water (16 ounces).

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cough but little secretion; in the dyspepsia of persons disposed to phthisis; and for eczema and prurigo; also for lithuria, though less often than those of Vichy.

The baths at Ems are much used. The well-known *Bubenquelle* is a warm ascending vaginal douche, which has a reputation in inflammatory and engorged conditions of the uterus.

Luhatschowitz (in Moravia) is situated in a pleasant valley of the Carpathian mountains, 1,600 feet above the sea. The springs, four in number, are cold, and contain in each pound from 30 to 60 gr. of bicarbonate of soda, 20 to 30 gr. of chloride of sodium, with traces of iodide and bromide of soda, and a large amount of carbonic acid (Braun). "They are the ideal of strong carbonated muriatic soda waters," and are valuable in severe catarrhal conditions, especially in chronic gastric catarrh, and in abdominal congestions and gouty exudations. In cases of hyperæmic enlargement of the liver, they even come into competition with Carlsbad water, and in cases where the strong soda waters of Vichy, Bilin, etc., have failed in their effect, it is well worth while to try a water containing more chloride; this salt increases the effect of the carbonate. Whenever tissue-change is to be increased, and at the same time tissue-growth promoted, and the gastro-intestinal secretions stimulated, soda waters containing common salt are to be preferred.

La Bourboule, in the Auvergne district, 2,600 feet above the sea, has several springs of different temperatures and proportions, but all containing carbonate and chloride of sodium, and also appreciable quantities of arsenic.

CLASS 2 (c).—BITTER WATERS.

The Friedrichshall water, which is largely imported from a spring in Saxe-Meiningen, contains, in a pound, sulphate of soda 46 gr., sulphate of magnesia 39 gr., chloride of sodium 61 gr., chloride of magnesium 30 gr., and sulphate of lime and potash, with a small amount of carbonic acid (Liebig). This water is useful in small non-aperient doses for promoting tissue-change, and in aperient doses is frequently prescribed for habitual constipation, hepatic congestion, abdominal plethora, etc.

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The Hunyadi Janos waters are the richest bitter waters yet known. Sixteen ounces contain 138 gr. of sulphate of magnesia, 129 gr. of sulphate of soda, with 11 gr. of chloride, and 13 gr. of carbonate of soda. They are used in the same class of cases as those last mentioned, but are more active and are rather less unpleasant to the taste.

Püllna water is of the same character, but intermediate in strength between Friedrichshall and Hunyadi Janos, containing 123 gr. of sulphate of soda, and 93 gr. of magnesia, with carbonate of the same, and chloride of sodium.

Seidlitz contains no sulphate of soda, but 104 gr. of sulphate of magnesia.

The once famous **Epsom** well contains in the pound 240 gr. of sulphate of magnesia, to which it has given its name.

The Beulah **Spa** (Norwood) contains 61 gr. of Epsom salt, with 9 gr. of soda sulphate, and some chloride.

The Streatham and **Kilburn Wells** resemble the Beulah Spa.

Purton Spa, near Swindon, has 23 gr. of each sulphate, together with chloride, lime sulphate, and some carbonic acid (which is deficient in most waters of this class); also traces of bromides, iodides, and sulphuretted hydrogen. This water is used as an "alterative stimulant" in strumous sores and enlarged glands, threatened consumption, hepatic disorders, rheumatism, chronic skin-disorders, and uterine derangements. Half a pint to a pint of the water is taken before breakfast, and another half-pint in the evening. The air of the place is dry and bracing.

Cheltenham possesses saline springs of several qualities. That of the *Royal Old Well*, first noted for the cure of George the Third, contains chiefly chlorides of calcium, sodium, and magnesium, with sulphate of soda and a little carbonic acid.

The Pittville Saline contains an unusual proportion of *silica*. *Spring No. 4, Montpellier*, contains a large amount of common salt (52 gr. in the pint), with 17 gr. sulphate of soda, and 14 gr. of magnesia, but is deficient in carbonate of soda and carbonic acid. This might be remedied, as Dr. Macpherson suggests, by adding a certain quantity of Bilin or of Vals water, and the temperature might be graduated, and very useful results again

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obtained from these waters. The *Montpellier* baths are well arranged, and include vapour douches and medicated vapour baths.

In winter the mild and equable, though rather moist climate, would even give an advantage over more distant Spas. By the Cotswold Hills the town is sheltered from N. and E. winds. The season is from mid-April to October.

At Leamington, the saline spring *Old Well*, contains in the pound 40 gr. of soda sulphate, 40 gr. of sodium chloride, 20 gr. of calcium chloride, 3 gr. of chloride of magnesium, traces of bromine and iodine, and 2 cub. in. of carbonic acid; also nitrogen and oxygen; temperature, 48° F. These waters are alterative, and are slightly aperient, more active than those of Cheltenham, and hence suitable for invalids of "torpid habit." I have used them with advantage in hepatic derangement.

The town is clean and pleasant, less protected by hills than Cheltenham, and hence the air is rather colder and more bracing; it is humid, but not raw.

At **Scarborough**, the *South Well* contains 28 gr. of sulphate of magnesia with 13 gr. of sulphate and 6 gr. of carbonate of lime, some common salt, and a trace of iron. The amount of lime is rather too large for cases requiring purgative waters.

CLASS 2 (d).—COMPOUND SODA WATERS.

Carlsbad, in Bohemia, situated on the banks of the Töpel, in a narrow valley 1,200 feet above the sea, is one of the principal, as it is the oldest of German Spas. The season is from the end of May to the end of September; at other times the climate is "rough," though in May it is often not more than fresh and bracing. Amongst the advantages of Carlsbad, Braun reckons the careful diet, and amongst the disadvantages, "an excessive use of coffee." The valley is rich in warm springs, which differ little in their fixed constituents though much in their temperature and gaseous contents. The *Sprudel*, which forms a fountain several feet high, giving off clouds of vapour, has a temperature of 164° F., contains 11·8 cub. in. carbonic acid, and sulphate of soda 18 gr., chloride 7 gr., carbonate 10 gr., with a little lime, magnesia, and iron. The *Schlossbrunnen* at 124° F. contains 17 cub. in. carbonic acid. The *Markbrunnen* at 130° F. contains in addition some iodide and bromide of sodium.

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Carlsbad waters are efficacious in several forms of dyspepsia, *e.g.*, when gastralgia and flatulence occur principally after meals, and when catarrhal conditions of stomach or intestine are present, and morning vomiting, or diarrhœa alternating with constipation. For corpulence, with its various troubles, they are a tolerably sure and gentle remedy, independently of violent evacuations. In jaundice, and a tendency to gall-stones and allied conditions, the waters diminish the inflammation and tumefaction in the gall-ducts, and thus enable calculi to pass more easily. In hepatic and splenic enlargement following malarial fevers, especially if constipation be marked, and in passive hyperæmia of the portal system and abdominal viscera occurring in stout florid persons with a tendency to hæmorrhoids, and generally sluggish venous circulation, Carlsbad waters are very effective. "Old Indians with enlarged livers often derive remarkable benefit." The hypochondriasis dependent more or less on the above-named conditions is also relieved. In gout and gouty conditions without much joint-affection, especially in patients with abdominal plethora and commencing atheromatous change in the vessels, in rheumatoid arthritis, sciatica, and in the tendency to uric acid concretions and consequent catarrhal affections of the urinary organs, Carlsbad waters are often quite as useful as the stronger alkaline waters. In cases of the *slower* and *milder* form of diabetes, the use of Carlsbad waters has rapidly and considerably diminished the excretion of sugar, and after some months has effected great improvement in the general condition in many instances. Even in serious cases, provided that they are not very acute and rapid in their onset, and not accompanied by phthisis, the same waters have often effected an improvement, and checked the progress of the disease.

In these observations I find myself in agreement with Seegen and Braun, and have only to add that the course at Carlsbad need not, and should not, be so conducted as to "purge, lower, and starve" the patient. We sometimes hear complaints of the depression and debility induced, and certainly, an excessive use of the waters is very lowering, but effective therapeutical results may be obtained without this. The diet, though restricted, should be nourishing, exercise

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moderate, not exhausting, and mental and bodily rest for some time after the treatment is very desirable. Baths of the cooled mineral waters are often beneficial, but are less used now than they formerly were.

Marienbad, also in Bohemia, and about five hours' drive from Carlsbad, is situated in a broad and beautiful valley, about 1,900 feet above the sea. The air is not mild, but is pure and dry, "and colds are less often taken here than at Carlsbad." The season begins somewhat earlier, viz., at the beginning of May, and it lasts until the end of September. Marienbad is the principal representative of cold gaseous sulphated soda waters, and the springs most used, the *Kreuz* and the *Ferdinandsbrunnen*, are stronger than the Carlsbad springs, and contain more free carbonic acid. They are more aperient, and given therefore in smaller doses (one to six tumblerfuls), or to patients who need more purging. In other respects, and excepting in diabetes, these waters are used like those of Carlsbad. They contain some iron, which, however, is not of importance, unless in the *Kronprinz-Rudolf* spring.

The *Carolinen* and *Ambrosius* springs are gaseous, weak in saline constituents, but containing some iron. The *Marienbrunnen* is used for drinking as well as for water and carbonic acid baths. The *Moor* or *mud-baths* at this Spa are also in request, and are prepared with black mineral powder brought from a neighbouring peat-bed. The *gas-baths* relieve myalgic and neuralgic pain, and soothe the *general* nervous system, while they stimulate that of the uterus; the *mud-baths* stimulate the skin and promote the healing of ulcerations, and the absorption of glandular swellings.

Franzensbad, near Eger, in Bohemia, 1,300 feet above the sea, has a fresh climate and good arrangements. The waters resemble those of Carlsbad, but are colder, and have more carbonic acid, and also more sulphate of soda (18 to 27 gr., with chloride, carbonate, and some iron). The treatment at this Spa has always been milder and more stimulating than at Carlsbad, and better adapted for anæmic, weak, thin, and perhaps hypochondriacal or hysterical subjects. In such cases, and especially in women who have become anæmic with spinal irritation and uterine disorder, benefit is obtained here when

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stronger and more pronounced chalybeates would not agree. Digestion is promoted, the nervous system strengthened, and the circulation stimulated.

Mud and gas-baths are also much used here, and are beneficial in chronic skin-disease and ulceration, rheumatism, gouty deposits, and paralyses when no active central disease is present.

Tarasp, in the Lower Engadine, canton Grisons, situated on the River Inn, amidst fine Alpine scenery, 4,000 feet above the sea, has recently risen into fashion, and is one of the most interesting and valuable Spas. The rarefied pure air acts as a powerful stimulant or tonic, and the summer climate is temperate and pleasant, whilst the conditions of life are much more simple than at Carlsbad, Vichy, Marienbad, etc. The ingredients of the waters are the same as those of Franzensbad, Marienbad, or Carlsbad; the chief springs are the *great*, or *St. Lucius*, spring, and the *little*, or *St. Emerita*, spring, having 16 gr. of soda sulphate, 29 gr. of chloride, about 40 gr. of bicarbonate, 17 gr. of lime, 7 gr. of magnesia, an effective proportion of iron, and a large amount of carbonic acid.

These are used in the cases already described as suitable for Carlsbad and Marienbad, except that there is not yet an equal experience as to diabetes; on the other hand, cases of bronchial catarrh, and even of tuberculosis in an early stage, and especially when complicated with hepatic troubles, have derived much advantage at Tarasp.

CLASS 2 (e).—COMMON-SALT WATERS.

Homburg, in Prussia, about nine miles from Frankfort, pleasantly situated on the southern slope of the Taunus Mountains, 600 feet above the sea, has a fresh and bracing climate even in the summer. The *Elisabethbrunnen* (the most-used spring) contains 75 gr. of chloride of sodium, the *Kaiserbrunnen* 55 gr., whilst both have also other alkaline chlorides, lime, magnesia, a little iron, and much carbonic acid, at a temperature of 50° F. (cold). The *Ludwigsbrunnen* contains only about half the amount of chlorides, and the *Luisenbrunnen* scarcely any calcium or magnesium.

The two springs first named are stronger than those of Kissingen, and are given in doses of two to four tumblerfuls in cases of

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dyspepsia and gastro-intestinal catarrh, constipation, strumous glandular enlargement, gout, obesity, hypochondriasis, etc. The *Luisenbrunnen* is "very suitable for anæmia and Indian cachexia."

Kissingen, about thirty miles from Würzburg, and 600 feet above the sea, in the pleasant valley of the Saale, is the main representative of cold, moderately-strong gaseous salt springs, and is one of the most fashionable watering-places of Germany. The principal springs are the *Ragoczi*, the *Pandur*, and the *Maxbrunnen*: the latter is a very weak salt water; the other two are nearly equal in strength, containing more than 40 gr. of chloride of sodium with small quantities of other alkaline chlorides, 4 gr. of sulphate of magnesia, 2 gr. of lime, a trace of iron, and much carbonic acid (40 to 48 cub. in.); the temperature is 51° F. (cold). The *Ragoczi* is generally taken in the morning (three to six glasses); the *Pandur*, being somewhat milder, in the evening. They quicken the circulation, alter and stimulate the gastro-intestinal secretions, and are valuable in dyspepsia, with eructations, flatulence, and constipation, in some gouty and calculous cases, in moderate degrees of hepatic and renal congestion, in strumous and tubercular enlargement of glands, etc.

In prescribing salt springs for cases of chronic dyspepsia, we should bear in mind that, as a rule, they are best taken *cold*, because a high temperature counteracts the intended irritant effects, and causes too rapid absorption of the salt. They are unsuitable for cases of excessive acidity which is increased by chlorides. The water should not be concentrated, and the dose should be small, and carbonic acid much assists its digestion. On the other hand, in some cases of gastric catarrh, the cold waters are not well borne, and then recourse is had to the *warm* spring of Wiesbaden. The strong salt bath of the *Soolsprudel* is much used, but Braun objects to the large amount of carbonic acid given off from it and inhaled by the lungs, as being apt to cause giddiness and dyspnœa.

Wiesbaden, capital of the former Duchy of Nassau, is 323 feet above the sea, and is situated beautifully on the southern slope of the Taunus Mountains, five miles N.W. of Mayence. The climate here is mild, in winter being one of the warmest in Germany; in spring and autumn usually fine; but at midsummer

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hot and relaxing. The season is from June till September. The principal spring is the *Kochbrunnen*, which rises like a boiling well, at 150° F., emitting clouds of steam. Its constituents are similar to those of the Kissingen *Ragoczi*, viz., chloride of sodium (52 gr. in the pound), carbonate of lime (3 gr.), and traces of potash, magnesia, iron, etc. The amount of carbonic acid is much less (6 cub. in.); the temperature much higher. The amount of chloride is slightly greater than that at Kissingen, but yet larger doses of the water can be taken, and increased intestinal secretion less often occurs from it. Hence, if the gastric condition does not especially need the stimulus of cold, the warm spring is to be preferred when the strong effect of salt on the blood is desired.

In cases of chronic inveterate gout which we can scarcely hope to *cure*, but which we can benefit by moderate increase of tissue-change whilst keeping up nutrition, these springs are most useful. They are useful, also, in chronic eruptions with hepatic and abdominal congestion, and in chronic rheumatism, in which disorder and in chronic paralyses the warm saline baths are specially indicated.

They may be injurious in debility, in uterine congestion, and in tendency to apoplexy or other hæmorrhagic conditions.

At Wiesbaden there are also hydropathic establishments, and the ophthalmic hospital of Dr. Pagenstecher.

Baden-Baden, 616 feet above the sea, is situated in a beautiful valley of the Black Forest, six miles from the Rhine. The air is pure and mild, so that baths can be taken late in the autumn, and the season is from the beginning of May until October. The general arrangements are agreeable, and the influx of visitors very large. Of the numerous springs, only the *Ursprungquelle* need be mentioned. It contains 18 gr. of chloride of sodium, and 2½ gr. of lime sulphate, with traces of iron carbonate, but very little free carbonic acid.

Gout and rheumatism of only moderate severity, dyspepsia and impaired nerve-condition from overwork, etc., various manifestations of the scrofulous diathesis, are all favourably influenced by the waters of Baden-Baden, which are taken internally and used as baths.

Soden, in Nassau, near Frankfort, 440 feet above the sea,

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contains many tepid salt springs varying in their proportion of chloride from 18 to 109 gr. The amount of carbonic acid is rather large.

The climate is mild, equable, and moist, but very hot in summer. Besides being suitable for the class of cases already mentioned, Soden has a special reputation in chronic catarrhal conditions, with or without tendency to phthisis. Near at hand, at Kronthal, are good chalybeate springs, and the bracing health-resort of Falkenstein, which is 1,700 feet above the sea, well wooded and sheltered from excessive sun and wind, and forming a good residence both in winter and summer for the earlier stages of phthisis.

Reichenhall, in Bavaria, lies in a sheltered position, near fine Alpine scenery, and has a mild climate, at its best in May and autumn—rainy in the summer. Of its salt springs, the *Edelquelle* is one of the strongest in Europe, containing 23 per cent. chloride of sodium, temperature 57° F. The waters are used in warm, tepid, douche, and wave-bath, and also by inhalation, patients walking between large hedges, 40 feet high, made of twigs, on which the salt water trickles and evaporates: the air of a large room is also kept impregnated with salt spray, and the breathing of such air for a limited period daily is found useful in catarrhal conditions of the chest and stomach (Burdon Sanderson, Practitioner, vol. i.). There are similar chambers at Kreuznach, Rehme, and a few other places.

Kreuznach, in Rhenish Prussia, pleasantly situated in the Nahe Valley, 286 feet above the sea, "is the chief of sool-baths" (Braun).

The climate is mild in the early spring and late autumn, hot in the summer. The season extends from the end of April until the beginning of October. The *Elisenquelle*, or *Elizabeth-brunnen*, contains 73 gr. of chloride of sodium, 13 gr. chloride of calcium, 4 gr. chloride of magnesium, traces of potassium, lithium, iron, and minute quantities of bromide and iodide of magnesium. There is some carbonate of lime but no sulphate; no carbonic acid. Temperature, 54·5° F.

The water of the *Carlshalle* and *Theodorshalle* is weaker, the chloride of sodium being 59 gr. and 57 gr. respectively, whilst the *Oranienquelle* has 108 gr. of the sodium salt, and 22 gr. of

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chloride of calcium. The waters, which are bitter and rather nauseous, should be commenced in small doses, and are often taken with hot milk. The *Elisenquelle* readily acts on the bowels.

The warm baths at Kreuznach are used particularly strong, concentrated brine, or "mother-lye," being often added to the natural water, and the bath being prolonged for half an hour or an hour. This "mother-lye," according to the degree of its inspissation, contains in each pound from 100 gr. to more than 200 gr. of chloride of sodium, from 1,000 to 2,000 gr. of chloride of calcium, from 200 to 300 gr. chloride of magnesium, 130 to 160 gr. chloride of potassium, some iodide of sodium, chlorides of lithium and aluminum, and about 60 gr. of bromide of sodium.

The justly-esteemed Kreuznach system of treatment combines the use of these strong baths with injections, douches, etc., and drinking of the water—in small quantities, if a generally stimulating effect is desired, but in large doses for the absorption of scrofulous and other exudations. I have seen much advantage from it in congestion and chronic inflammation of the uterine system, in hypertrophy and induration of the uterus itself, and of the mammary gland, and in painful irregular menstruation connected with ovarian hyperæmia. It relieves, also, the local congestion and œdema commonly associated with uterine fibroma, and I believe that it even procures, sometimes, the absorption of such growths to some extent (*v.* p. 153).

Chronic eruptions and scrofulous ulcerations also receive benefit from Kreuznach water, and the local use of the "mother-lye" to distorted gouty joints has sometimes given me good results.

Braun compares with Kreuznach the more recent Spa of **Rehme** (Œynhausen), which is situated 134 feet above the sea, "in a broad and fertile valley watered by the Weser and the Werre," on the railway between Minden and Cologne. The climate is fresh but mild, and is less changeable than that of many other places; the water is very rich in chloride (240 gr.), and contains also sulphate; it is used principally in the form of warm bath, and differs from the Kreuznach bath mainly in the large amount of carbonic acid it contains. There are also

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carbonic acid baths (*v.* p. 242), a "wave-bath" in the river under the mill, and a large chamber filled with salt spray for inhalation.

Rehme is suitable for the same kind of cases as are sent to Kreuznach, but in a less advanced stage, and when the subjects are weaker, and too delicate for the stronger methods of the latter Spa. Benefit is said to be obtained from the baths specially in retarded convalescence after fever, fractures, etc., in general debility, anæmia, tabes dorsalis, spinal irritation, and even in spinal meningitis and paralysis. The spray is useful in catarrhal conditions of the respiratory tract.

Kreuth should be mentioned as an example of a high-situated salt Spa, being nearly 3,000 feet above the sea, amidst Alpine scenery, between Munich and Salzburg. It is sheltered and possesses a pure, rather moist, and particularly *still* atmosphere.

There are here a large "Kurhaus," a "whey-cure," and strong salt baths. The drinking springs contain mainly sulphates, or sulphur. Cases of irritable mucous membranes of scrofulous or tuberculous character are often benefited at this place.

Droitwich is a small salt-manufacturing town, six miles north of Worcester, and fourteen from Malvern. The climate is mild and equable, rather relaxing, and though the place itself is uninviting, there is fine open country in the immediate neighbourhood. There is now good accommodation for bathing, and an establishment close to the waters under the direction of Mr. Bainbrigge.

The proportion of saline ingredient is very high—far higher indeed than at any other known spring, there being about 2,500 gr. chloride of sodium, 38 gr. lime sulphate, and 39 gr. soda sulphate in each pound (D. T. Taylor). Used for bathing at about 95° to 112° F., these waters are stimulating and absorbent, and are very serviceable in relieving pain and exudations, and impaired power connected with chronic rheumatic and gouty conditions; also in lumbago and sciatica, in some chronic skin-eruptions, as psoriasis, in glandular scrofulosis, general debility after illness, etc., especially when this is associated with slow circulation and mental depression; serous effusions are also absorbed under their use, and they are said to have proved a powerful stimulant and restorative during the cholera epidemic of 1831. Strong brine

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baths can be used at a high temperature without the exhaustion and debility that follow an ordinary hot bath.

Woodhall Spa, near Horncastle, in Lincolnshire, has a dry and bracing climate, and is sheltered from north and east winds. The water contains a good proportion of sodium chloride (120 gr. in the pound), 21 gr. of calcic and other chlorides, and also about ½ gr. of bromide, and ¼ gr. iodide of sodium.

It is used in scrofulosis, and sometimes in chronic gout and rheumatism. Half a pint of it acts as a mild aperient.

There is a saline spring at Harrogate, somewhat similar to one at Kissingen, and called the "Kissingen water." It has more lime and less carbonic acid, and is moderately aperient. Most of the sulphur waters also contain a large proportion of chloride.

CLASS 3.—SULPHUR WATERS.

The sulphur baths of the Pyrenees have been famous from an early period. Most of them are natural baths (Wildbäder), in high mountainous situations, and with a rough climate.

Eaux-bonnes, department Basse-Pyrenées, 2,300 feet above the sea, situated in a narrow sheltered ravine at the foot of the Pic du Gers, about twenty miles from Pau, is rich in grand natural beauties, and has a remarkably pure fresh climate, though it is subject to great changes of temperature during the day.

The waters contain 0·18 cub. in. sulphuretted hydrogen to the pint, with but 2 gr. chloride of sodium, and 2 gr. of other salts, sulphates, and iodides, at a temperature of 90° F.

The dose at first taken is but small, often a tablespoonful, but this is increased gradually to a pint or more, and the good results are said to be so remarkable in tuberculosis and pneumonic consolidation of lung, in asthma, granular pharyngitis, pleuritic effusion, and scrofulous deposits, as well as in chlorosis, amenorrhœa, and atonic dyspepsia, that many physicians "have supposed the cures to be due to some as yet unknown element in the otherwise very poor water." The high situation of the Spa is probably a main agent in its action. The season lasts from June to mid-September, and residence is usually arranged for a month at a time during one or two seasons. Bathing is not

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much practised, but the patient is recommended to live as much as possible in the open air, and to complete the treatment by a course of sea-bathing at Biarritz.

Eaux-chaudes, situated four miles further on in the same valley, has waters containing sulphuret of sodium, sulphate of lime, etc., which are used more for baths than for drinking, in muscular rheumatism, neuralgias, chlorosis, etc.

Ponticosa, in Arragon, a day's journey from Eaux-chaudes, is situated in a valley of the Pyrenees, nearly 6,000 feet above the sea. The waters contain much nitrogen and sulphuretted hydrogen, with chlorides and sulphates. They increase the secretions and the appetite, but without exciting the circulation. They relieve the cough of laryngeal phthisis and bronchial irritation, and are suitable for cases of hæmoptysis, but not for softening tubercle. The best months are July and August.

Cauterets, department Hautes Pyrenées, 3,200 feet above the sea, in a narrow winding valley, has a pure and fresh, but rather variable climate. It contains more than thirty warm saline sulphuretted springs, some of which are highly stimulating, and give rise to feverishness and headache. The *Raillère*, which is famous for the cure of chronic bronchial catarrh, contains in one pound only 0·14 gr. sulphuret of sodium, 0·3 gr. sulphate of soda, 0·3 gr. chloride of sodium, 0·4 gr. silica, nitrogen, and traces of sulphuretted hydrogen, but the water is very warm (102° F.). It is used both internally and by bath, and sometimes gives strikingly good results in early stages of phthisis and strumous deposit, in gastric catarrh, uterine congestions and fluxes, also in chronic rheumatism and skin-diseases. Animals, especially horses, with catarrh or abnormal discharges, are also benefited at Cauterets. July, August, and September are the best months.

Barèges, department Hautes Pyrenées, 4,000 feet above the sea, with a bracing rough climate, is "the most famous of Pyrenean Spas." The sulphurous stimulating waters are hot (107° F., *Bain de l'Entrée*), warm (98° F.), and tepid (84°). They are limpid, have an oily nauseous taste, characteristic odour, and contain nitrogen and sulphuretted hydrogen, with small quantities of sulphuret, sulphate, and chloride of sodium, etc. On their surface is found a gelatinous pellicle called *barègine* or *glairine*, which is a nitrogenous organic substance,

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found in most sulphur waters, emollient, and supposed to be efficacious in chronic rheumatism. Sufferers from this complaint, and from sciatica, lumbago, and stiffness of muscles and tendons, visit Barèges in large numbers; it is celebrated also in paralysis, in strumous ulcerations, and especially in bone-disease and old gunshot wounds. The swimming-baths are much used, and the waters are taken internally. They are not suitable for "irritable nervous subjects, nor in heart-disease, nor tendency to inflammatory disorder" (Tanner). The season extends from early in June to mid-September. In July and August the crowding is sometimes so great that "invalids must leave their beds soon after midnight for their turns at the baths, and the air in the 'piscines,' from the small space allowed to each bather, is almost intolerable" (H. Weber).

Saint Sauveur, four miles from Barèges, has similar, but milder waters, which are much used by women and children for hysteria, neuralgia, leucorrhœa, and uterine derangements—"pre-eminently the French ladies' Spa" (Braun). The season begins earlier, and lasts later than at Barèges.

Bagnères de Luchon, department Haute Garonne, 2,000 feet above the sea, is charmingly placed in a broad valley, close to splendid scenery, enjoys a mild climate, has excellent arrangements for recreation and abundant sulphurous water, double the strength of those already mentioned. There are about fifty springs, varying in temperature from 63° to 132° F., and containing sulphuret and sulphate, sulphite, and chloride of sodium, other sulphurets, silica, lime, etc. Analysis detects only traces of sulphuretted hydrogen in the waters at the springs, but almost as soon as drawn, they become milky on account of some decomposition with development of this gas, and so much of it escapes from the large bath that the atmosphere above it contains more than 1 per cent. They are used in the same cases as Barèges and Cauterets, etc.

Aix-les-Bains, in Savoy, near Chambéry, 790 feet above the level of the sea, in a sheltered picturesque valley of the Alps, is a celebrated watering-place—the Agnæ Gratinæ of the Romans—greatly resorted to for its sulphurous springs, which are often of much value in chronic rheumatism, gout, neuralgia, and some skin-diseases, as well as in paralysis. The temperature of the

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waters varies from 100° to 117° F. They are chiefly employed for baths, the douche-bath being the one most in use. The hot water is made to fall in streams from a height of about 8 to 10 feet upon the patient, who is afterwards thoroughly rubbed, wrapped in blankets, sent home in a sedan-chair, and then put to bed. The climate is mild and relaxing. During the season the place is often unpleasantly crowded.

Aix-la-Chapelle, 534 feet above the sea, is the principal German sulphur bath. "The amount of sulphuret of sodium in the springs is small, compared with the Pyrenean baths, but the sulphate of soda is rather more, also the sulphuretted hydrogen, and in addition, there are 20 gr. of chloride, and 5 gr. of carbonate of soda, with traces of iodide and bromides. This combination is of much importance for drinking" (Braun).. The temperature of the water taken internally is often 130° F.

Warm baths (95° F.), prolonged from half to three-quarters of an hour, are also much used at Aix, with vapour baths, douches, and frictions, and the results of the combined treatment are very satisfactory in rheumatism, gout, chronic eruptive disorders, acne, psoriasis, and abdominal plethora; they are often good, though not so markedly, in paralyses, metallic poisoning, and chronic syphilis, but Braun throws scientific doubt upon the supposed special efficacy of the sulphur in these maladies, and connects the therapeutics more with the temperature and the amount of saline liquid. Mercury is also commonly used in the treatment of syphilis at Aix, not internally, but by inunction of mercurial ointment, from 1 to 1½ dr. being used daily after a warm bath. The value of the baths and water in the treatment of this disorder lies in their (1) increasing the specific action of mercury; (2) preventing salivation and other injurious effects of the drug; (3) keeping the skin in an active state, the glands secreting, and the pores free. The patients are directed to live well, eat freely of animal food, drink wine, and to be constantly in the open air. Rheumatoid arthritis is also treated with some success at Aix. The season begins early in June, and ends in September. As the treatment is highly stimulating, it is not suitable for apoplectic and hæmorrhagic cases.

Weilbach, in the Prussian province of Nassau, in the valley of the Main, on the eastern slope of the Taunus range, has a

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good sulphurous spring for internal use, the quantity of sulphuretted hydrogen amounting to 0·16 cub. in. Carbonic acid is also present; the amount of salts is small, a few grains only of chlorides and carbonates of soda, magnesia, and lime. "The life here is quiet, and almost solitary." This Spa is specially indicated in some cases of lung-disease, catarrhal or tubercular, when hyperæmic enlargement of liver exists, or congestion of the abdominal viscera with hæmorrhoidal tendency, and it will sometimes relieve when Carlsbad and other soda springs cannot be borne. Roth has given reasons for believing that sulphuretted hydrogen, taken in solution into the stomach, acts directly on the blood in the portal vein, forming a sulphuret with the iron of effete blood-corpuscles, and thus hastening their destruction, for the diminution of swelling in the liver under the influence of Weilbach waters is accompanied by a darker and, at length, black colouring of the fæces, in which a large amount of sulphuret of iron is found. This does not come from the water (which contains none of the metal), but either from the food or the blood, and in favour of its being from the latter is the fact that, as the liver decreases in size, an anæmic condition manifests itself in spite of plentiful nutrition. Roth, indeed, insists upon full meat diet during a course of these waters, and a chalybeate course is frequently required afterwards. Dr. Braun agrees with these statements, and himself derived much benefit from the waters when suffering from hæmoptysis connected with "hæmorrhoidal enlargement of the liver."

Generally they have rather a constipating effect, and do not increase the intestinal secretions like sulphate of soda waters, though irritation and diarrhœa may be occasionally excited. The refreshing feeling and appetite caused by saline gaseous waters are not felt at the time of drinking these waters, but real *hunger* occurs in the course of the treatment. Besides their medicinal use, already mentioned, in bronchial catarrh, etc., they are valuable in chronic metallic poisoning.

British Sulphur Springs.—**Harrogate**, about thirty miles west of York, is situated part on high level ground, about 600 feet above the sea, and part in a sheltered valley. It is surrounded by open and pleasant country, and has a pure and bracing though rather moist air; the sandy soil soon dries after rain.

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The *old sulphur well* and the *strong Montpelier sulphur well* are said to contain 25 cub. in. of sulphuretted hydrogen in the gallon of water, with alkaline and earthy chlorides and sulphides, and traces of bromide and iodide.

They are alterative, stimulant, diuretic, and aperient, and are taken in doses of from one to three tumblerfuls, at intervals before breakfast.

Milder sulphurous springs at the Victoria and Montpelier Gardens are also in use. They contain carbonate of magnesia, and are "antacid, alterative, diuretic, and deobstruent." Both these waters are naturally cold, but are commonly taken warm; they are used also for bathing, the arrangements for which are very good. There are also saline chalybeate and pure chalybeate waters. The social resources of Harrogate and the pleasant climate of summer and autumn (June till October) attract many classes of invalids, but the most suitable cases for treatment by the waters are—dyspepsia with inactivity of liver and bowels, especially when due to high living; constipation, obesity, swellings of joints and glands, chronic skin-diseases, gout and rheumatism, syphilis, etc.; cases of incipient phthisis and disordered menstruation in young women are also sent here with advantage, and make use of the warm sulphur baths whilst taking the chalybeate internally.

Moffat, in the upper part of Annandale, is 400 feet above the sea, with a good climate and picturesque surroundings. The water, which is cold, contains 2½ cub. in. sulphuretted hydrogen in the pint with 22 gr. of chloride, and 2 gr. of sulphate of soda. It is used internally in much the same cases as the Harrogate sulphur water.

Strathpeffer, in a beautiful part of Ross-shire, has several cold sulphur springs, containing a good proportion of the gas with alkaline and earthy sulphates and 16 gr. of lime salts; these latter render the water somewhat difficult of digestion, and constipating.

At **Llandrindrod**, in Radnorshire, there are sulphur wells of some reputation, described by Macpherson as "mild Harrogate waters." At **Builth** (the next railway station) there is a weak sulphur well, and a saline with 66 gr. of chloride; and at **Llanwityd** there is a weak saline spring with a large proportion

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(0·62) of sulphuretted hydrogen. The climate at these places is pure and bracing.

The principal sulphur wells in Ireland are at **Lisdoonvarna**, situated in a bare country, about twenty miles from Ennis (county Clare). They are said to contain ½ cub. in. of sulphuretted hydrogen, and are much used, but the accommodation is insufficient. There are also chalybeate springs of good quality.

CLASS 4.—EARTHY MINERAL WATERS.

Wildungen, in the principality of Waldeck, is 740 feet above the sea, and, besides a chalybeate, has three earthy springs.

The *Georg-Victorquelle* is a strongly acidulated spring containing 33 cub. in. of free carbonic acid, with 5 gr. of carbonates of lime and magnesia, a little alkaline sulphate, silica, and iron. The *Helenenquelle*, with 34 cub. in. of carbonic acid, has nearly 10 gr. of the earthy salts, with 8 gr. of chloride of sodium and bicarbonate, and a trace of iron. The *Thalquelle*, similar to, but weaker than the Helenenquelle, is more used. It exerts an antacid and diuretic effect, and the two other springs show this in a more marked degree. They are prescribed in vesical catarrh and uric acid concretions in the kidney, and may be either continued alone for a long time, or conjoined with Carlsbad, Vichy, or other more purely alkaline waters.

Leuk (**Leukerbad, Loèche-les-Bains**), on the north bank of the Rhone, in the canton Wallis, at the foot of the Gemmi Pass, is 4,670 feet above the sea. The principal spring, the *Lorensquelle*, contains 10 gr. of lime sulphate in the pound, with some magnesia and traces of alkalies and iron. It is used internally in doses of one to five tumblerfuls taken at a high temperature (122° F.), and is rather constipating, but diuretic and diaphoretic. Braun attributes more importance to the *warm fluid* than to the ingredients.

But the speciality of Leuk is the mode of bathing. There are four public pools, each three or four feet deep, and accommodating about forty bathers, who, clothed in flannel, amuse themselves with conversation, games, etc., and spend the greater part of the day in the warm mineral water. The time is gradually extended from half an hour to five and even eight

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hours in the day for about ten days, and then gradually diminished in the same proportion, so that a course is completed in about twenty-five days. The diseases thus treated include gouty and rheumatic exudations, visceral enlargements, scrofulous and other ulcerations, and chronic eruptions, such as psoriasis, eczema, and prurigo. In such cases the lime sulphate acts as a local stimulant, and often causes an erythematous or pustular eruption (poussée), which is the signal for diminishing the baths. The high situation of the Spa enables such stimulating treatment to be better borne than it would be elsewhere.

Weissenburg, in the canton Berne, near Thun, 2,758 feet above the sea, is situated in a narrow sheltered ravine surrounded by mountains and pine trees. The air is calm, mild, and moist, but the weather variable; the mode of life is simple. The waters are similar to those of Leuk, but with more lime sulphate (17 gr.) and magnesia, much less carbonic acid; temperature, 74·8° F. Excellent results in bronchial catarrh and some forms of phthisis are obtained at Weissenburg, but are to be explained rather by its general conditions than by the composition of the water (Braun). Pleuritic exudations are said to be rapidly absorbed. The waters purge in full doses (six to eight glasses), and sometimes cause dyspepsia at first. Baths are not used in phthisical cases (Rohden).

Lippspringe, a small town near Paderborn, 441 feet above the sea, on a soil of chalk and sand, has a lime spring containing 5 gr. of sulphate and 2 gr. of carbonate, with some sulphate of soda and magnesia, a little iron, some carbonic acid, oxygen, and nitrogen, the latter in comparatively large proportion (1·4 cub. in.); temperature, 70° F. Small doses (12 oz.) constipate, medium quantities regulate the digestion, whilst 30 to 36 oz. commonly relax the bowels. It is remarkable that under treatment at this place, the appetite and assimilative power of phthisical patients in an advanced stage have improved so much as to lead to an increase in weight of "10 lbs. in four weeks, and 21 lbs. in thirteen weeks." Whatever the explanation, it would seem that the diseased lung-tissue is gradually expectorated during the treatment, with slight fever and moderate suppuration, so that cavities heal up, and a cure

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may be completed at higher and drier health-resorts. Possibly the heat of the water and its slight amount of gas, taken fasting, facilitate expectoration and assist in the softening of cheesy deposit and loosening of catarrh (Rohden). Possibly, also, the moisture of the atmosphere assists by keeping in the water of the lungs and skin; the climate is very equable and cool; moist west winds prevail; the noons are cooler, and the mornings and evenings warmer than in other places of the same latitude. Inhalations of nitrogen are also used here.

Inselbad, near Paderborn, is commonly mentioned with Lippspringe as a resort for phthisical subjects, on account of the nitrogen in its medicinal waters. The gas is also inhaled. The weak salt spring (6 gr. chloride, with 2 gr. lime carbonate) is considered valuable in hæmoptysis (Hörling).

CLASS 5—"INDIFFERENT THERMÆ," or BATHS WITHOUT ACTIVE CHEMICAL INGREDIENTS.

Buxton, about thirty miles north of Derby, is situated on a lime-stone mountain range, 900 feet above the sea. The air is pure and bracing, but subject to sudden variation, and the rain-fall is rather large. The season extends from April to November, but June is generally soon enough for a visit, for there are cold, sharp winds in the early spring, as well as in late autumn and winter. The quantity of solids contained in the mineral water is not more than 2 gr. (lime, etc.) in 16 oz. (Lyon Playfair); the gas obtained from it consists of about 99 parts per cent. of nitrogen, 1 of carbonic acid, and a trace of oxygen. Temperature, 82° F.

The water is taken internally, but used mostly for bathing at the natural temperature for about five minutes, and at a raised temperature (93° to 96° F.) for fifteen minutes (Robertson). The plunge, swimming, and douche-baths are very good. A course at Buxton is often beneficial in gout and rheumatism, especially when of a chronic character; also in old sprains and muscular contractions, and in debility, "when the vascular, nervous, or digestive systems require stimulating." It is unsuitable for hæmorrhagic cases. Dr. H. Weber compares Buxton to Schlangenbad.

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Bath, Somersetshire, has four warm mineralized springs in the southern part of the town, varying in temperature from 104° to 120° F. The solid contents amount to about 10 gr., in the pound, of alkaline and earthy salts, with a little silica and iron. Nitrogen exists in rather large quantity, and oxygen and carbonic acid in small amount. From a half to two tumblerfuls are taken once or twice daily, with the usual effect of slightly raising temperature, quickening circulation and appetite, and promoting secretion. Sometimes, however, headache, depression, and pyrexia occur.

The accommodation for bathing is very good, and is available the whole year, but the greater number of visitors go between November and April, for the climate is relaxing in the summer; at other times it is mild and equable. Cases of gout and rheumatism of moderate severity, neuralgia and myalgia, contracted joints, etc., some dyspepsias, rheumatic or metallic palsies, leucorrhœa, and *chronic* skin-diseases, as psoriasis and eczema, often receive benefit at Bath. I have, however, seen much irritation in several cases of subacute eczema sent to these baths, and there seem to be many nervous irritable subjects with whom they do not agree. It has been called the English Teplitz.

Teplitz, in Bohemia, 648 feet above the sea, with agreeable surroundings, and a moderately good but changeable climate, is one of the most frequented Spas in Europe, having arrangements for 4,000 baths a day. They are generally given very warm, 105° to 109° F., and followed by one to two hours' gentle perspiration in bed. They are highly stimulating and rather predispose to catching cold; a subsequent course of sea-bathing increases their value, which is certainly great in many cases of gout and rheumatism.

Plombières, in the Vosges, in a deep and narrow valley, 1,300 feet above the sea, is "the French Teplitz." The springs are but slightly mineralized, but are very warm (143° F.). The water is taken especially in chronic gastralgia and catarrh of the stomach, and the hot baths are used much in the same manner as at Teplitz, but are commonly more prolonged.

Pfäffers and Ragatz, in the canton St. Gall, have also indifferent thermæ of the same character. The former, in a

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narrow ravine, 2,000 feet above the sea, has warmer baths, but is much less pleasantly situated than the latter place, which lies in a broad bright valley 500 feet lower down. The waters are taken in four tumblerfuls, and the baths used for half an hour twice daily, in nerve-irritability, neuralgia, hysteria, etc. Season, May to September.

Gastein, a few hours' drive from Salzburg, in a beautiful part of the Tyrol, is one of the highest baths, being 3,300 feet above the sea-level. "The houses are grouped round the edge of a mountain torrent, which forms a splendid waterfall," and are surrounded by grand and mountainous scenery. The climate is bracing, and rather rough and rainy, but not so variable as at other mountainous resorts. The social tone is monotonous and quieting for excitable subjects. The waters are clear and soft, temperature 96° to 114°, and slightly mineralized—one pound contains only 2½ gr., and more than half of this is sulphate of soda; they are used in warm baths for from ten minutes to an hour. The methods in use at Gastein are milder than at Teplitz, though there are some similar very hot baths for rheumatic exudations and atonic paralysis. The place has a high reputation in such cases, also in hysteria, hypochondriasis, and impotence. If the last-named condition be due to over-excitability of the lumbar cord from sexual excess, it may be relieved by sedative baths; but if from spinal paralysis, it is not likely to be so, and hence very contradictory results have been recorded by different physicians (Braun). Sometimes the cold water system, or that of Rehme or Schlangenbad, will succeed better. It is especially suited for slight cases of spinal congestion or weakness, marked by fatigue on slight exertion and referred especially to the lower spine, by a sense of weight or slight anæsthesia, ataxia, or startings after much walking or standing, sometimes irritability of bladder—such symptoms may be quite removed by a comparatively short course.

Wildbad, in the Wurtemburg Black Forest, 1,330 feet above the sea, is situated in a beautiful richly-wooded but narrow valley, and from its excellent arrangements has become a fashionable bath in spite of a somewhat variable climate. The waters are soothing and refreshing, and are used externally, especially in paralytic cases.

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Schlangenbad is close to Wiesbaden and to Schwalbach, in a pleasant valley, 900 feet above the sea, with a mild, fresh, and equable climate, and is well suited for securing the sedative tonic results of thermal treatment. The arrangements are not on a large scale, but are excellent, the life quiet, and the surrounding forests offer varied and sheltered walks in summer, from June till August. The waters contain only a few grains of soda, lime, and magnesia, at 81° to 86° F. They are used chiefly in the form of warm baths at 87° to 92° in tabes and spinal congestions, and for allaying nervous irritability. Mud-baths are also employed for the same purpose and for improving the skin-condition.

CLASS 6.—CHALYBEATE WATERS.

Protocarbonate of iron, or ferrous carbonate, is contained in a large number of mineral waters, in amount varying from mere traces to several grains in 16 oz. The most used and the most successful contain between 0·3 to 0·9 gr., with free carbonic acid.

It is a truism that minute quantities of iron taken at mineral springs, with the advantages of change, pure air, and often an elevated situation, produce effects as good as, or better than can be obtained from, medicinal doses administered in the ordinary manner. If 0·5 gr. be taken as an average proportion in 16 oz., then only this amount, representing but 0·14 gr. of metallic iron, is taken with each pint; but when once the condition has begun to improve, the iron contained in *food* is better assimilated, so that improvement is continued by natural processes. A few cubic inches of carbonic acid suffice to keep the iron salt in solution (Fresenius), but on exposure to air part of the acid escapes, oxygen is absorbed, and hydrated ferric oxide is deposited. A chalybeate water will keep for some time if not shaken, and it may be heated up to 87° F. without much deposit of iron. A few waters contain sulphate or perchloride.

Of alkaline waters, Gieshübel, Ems, Salzbrunn, Bilin, Luhatschowitz, Apollinaris,—of alkaline saline springs, Carlsbad, Marienbad, Tarasp, Franzensbad,—and of more markedly saline waters, Kissingen, Wiesbaden, Baden-Baden, Soden, Kreuznach,

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Rehme, Hall, Adelheidsquelle, and Harrogate, may all be mentioned as slightly chalybeate, and at almost all the great Spas there are some pure stronger chalybeates for use besides the saline; but amongst those frequented specially for the *iron* waters we may refer to the following:—

The Kniebis baths in the Badish Black Forest, 1,200 to 1,900 feet above the sea, with beautiful scenery and quiet bath life.

Bocklet, near Kissingen, 620 feet above sea-level, has a mild climate and a rich saline chalybeate water.

Driburg, near Paderborn, 633 feet elevation, is situated in a pleasant valley, and has a fresh climate.

Königsworth, near Marienbad, 2,000 feet above the sea, in a sheltered position on the southern slope of a mountain, has a pure fresh climate recommended for chronic pneumonic and phthisical tendencies. The springs contain from 0·4 to 0·6 gr. of iron bicarbonate, 5 to 6 gr. of salts, and 30 cub. in. carbonic acid.

St. Moritz, in the Upper Engadine, a day's drive from the Coire station, situated in an Alpine valley, rich in vegetation, and 5,400 feet above the sea, has become justly popular, for the air is very refreshing and agreeable even to delicate subjects, especially to those of sluggish circulation and unexcitable nervous system. It is clear and dry, and though dew falls, there is little fog or mist. For a winter residence it is also recommended. The springs contain 0·18 to 0·25 gr. of iron, with a little soda and lime and much carbonic acid (31 to 37 cub. in.), so that the baths are somewhat gaseous: temperature, 39° to 41° F.

Santa Catarina, in Upper Italy, near Bormio, is even higher in situation (5,600), and in waters and surroundings, and scenery, much resembles St. Moritz.

Pyrmont, in the principality of Waldeck, situated in a deep valley 400 feet above the sea-level, with a healthy, mild climate, and extensive, somewhat old-fashioned arrangements, was formerly the most celebrated of iron Spas. It has one of the stronger compound springs, containing 0·57 of the mineral with lime, magnesia, and free carbonic acid (29 cub. in.). There are also salt springs and baths.

Schwalbach, a clean, long-stretching town, on a sloping,

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sheltered plateau of the Taunus range, is 900 feet above the sea. It is easily reached from Wiesbaden. It has pure fresh air, excellent arrangements, and strong iron springs, the *Stahlbrunnen* containing 0·64 gr., the *Weinbrunnen* 0·44 gr., the *Paulinen-brunnen* 0·51 gr., with lime, magnesia, soda, and much carbonic acid (40 to 50 cub. in.): temperature, 47° to 50° F.

Spa, in Belgium, 1,000 feet above the sea, beautifully placed amongst the Ardennes forests, at the foot of a lofty wooded mountain, which shelters it on the north, is one of the most frequented iron springs on the Continent at any time from May till September; afterwards the climate is apt to be wet and cold. The *Pouhon* spring contains 0·37 gr. of iron, with only 3 gr. of salines and 8 cub. in. carbonic acid. The *Barisart* has more gas and less iron.

At Harrogate, the *Muspratt* spring contains perchloride of iron with salines—an unusual and effective combination. The Tewit contains 0·135 gr. of carbonate, with a little saline.

Tunbridge Wells, about thirty miles south of London, 300 feet above the sea, with healthy climate and beautiful environs, has a pure but weak spring, used formerly much more than it is at present. It contains about ¼ gr. of iron oxide in the pint, but little carbonic acid, so that it is not sparkling. It might be taken with advantage in Apollinaris water.

At Brighton there is a spring, now but little used, which contains sulphate of iron in small amount, and at Malvern, Bournemouth, Sandown, and many other health-resorts there are chalybeates more or less available.

THERAPEUTICAL ACTION.—With regard to the therapeutical use of iron waters, formerly invoked so constantly whenever "strengthening" was desired, we must note that more discrimination is now exercised. Sea-bathing, mountain air, quinine, nux vomica, and other remedies are more used, and iron is ordered more exclusively for true anæmia and chlorosis. Modern medicine, however, recognizes anæmia arising from fever, pneumonia, and most acute disorders quite as distinctly as from hæmorrhage (*cf.* Coupland, Gulstonian Lectures, March, 1881). The more rapidly it is produced, and the more directly from loss of blood, or of component parts of blood, as in hæmor-

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rhage, exudation, or suppuration, the greater the indication for iron in full doses: indeed, officinal preparations are often better in such cases, and chalybeate waters find their use only in later stages.

Their advantages are that they contain a compound (generally a bicarbonate) which is readily digested by the stomach, since it is easily changed into lactate or chloride; that this is well diluted, and so more readily absorbed; and that the free carbonic acid given at the same time is a useful stimulant to the gastro-intestinal membrane. On the other hand, these conditions, under certain circumstances, may be disadvantageous, and a full dose of more concentrated preparations will give better results: for instance, symptoms of *congestion* of the head or chest, under a course of carbonated chalybeate, are referred by many physicians to the carbonic acid rather than to the iron, and in such cases an ordinary pharmaceutical preparation may agree better (Braun).

Simple (true) chlorosis, occurring during the developmental period, seems connected with *direct* loss of iron, which sometimes manifests itself by an increase in the amount passed in the urine (Braun); and it is in this form of anæmia that the administration of iron proves most successful. It is seen amongst the poorer or the middle classes more frequently than amongst the higher, in whom chlorosis is often complicated with mental excitement or depression, hysteria, leucorrhœa, etc.

The more indirect the anæmia—when arising, for instance, from impaired general nutrition, with deficiency of albumen and fibrine rather than of blood-cells, or from special derangement of organs or nerves—the slower and the more uncertain is the effect of iron; the anæmia of mal-nutrition is often better treated by nourishment and hygiene, while the former connected, *e.g.*, with hysteria, may be aggravated by iron internally, but relieved by *indifferent* baths as at Schlangenbad.

Anæmia, complicated with or dependent on chronic discharges, such as from caries of bones, diarrhœa, catarrh, etc., is a generally impaired condition of the blood, and should be also treated dietetically, by meat, fat, milk, and with due attention to hygiene. The anæmia of prolonged lactation, which is often accompanied by dyspepsia, requires preliminary medical treatment—weaning the infant being naturally the first indication.

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In amenorrhœa and other disorders of menstruation, the indication for iron is the degree of anæmia. We should endeavour to put the blood in such a condition that nature can secure from it a healthy result.

Sometimes a salt water (such as Kissingen) and careful hygiene will give better results than iron, while in other cases a compound somewhat purgative iron spring, as at Franzensbad, will be more beneficial. Generally speaking, constipation in these cases requires purgative sulphated or saline waters, whilst if dyspepsia or diarrhœa be present, they must be combated by appropriate treatment.

Atony of the stomach and intestinal canal is often benefited by a course of iron waters, and the accompanying carbonic acid becomes also valuable in this disorder, which frequently complicates chlorosis and anæmia.

Certain neuroses are also much relieved by chalybeates, but the main indication for their use is the presence of anæmia.

Most iron springs are cold, but are much better borne by chlorotic girls if warmed by the addition of hot water or whey.

ACIDUM ACETICUM—ACETIC ACID, $HC_2H_3O_2$, = 60.

Acetic acid occurs in the Pharmacopœia in three grades of strength—(1) The glacial or concentrated acid, which is three times as strong as (2) the ordinary acetic acid, which itself is eight times stronger than the (3) dilute acid. Vinegar is an impure form of the last mentioned.

ACIDUM ACETICUM GLACIALE—GLACIAL ACETIC ACID.

Preparation.—This acid being volatile, may be liberated from any acetate by distilling it with a fixed acid, as sulphuric, but its preparation is now left in the hands of the manufacturers.

Characters and Tests.—At the mean temperature of the air, the acid is liquid, but at 34° F. it crystallizes in colour-

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less prismatic crystals, which are not unlike ice, whence the name, glacial. This form is retained up to a temperature of 48° F. The liquid acid has a pungent acetous odour, and is remarkable for the variations in its specific gravity according to its dilution. By the addition of water, the sp. gr. is *raised* from 1·065 till it reaches 1·073 (corresponding to 84 per cent. of anhydrous acid, $C_4H_6O_3$), but any further addition of water permanently lowers it.

ACIDUM ACETICUM—ACETIC ACID.

PREPARATION.—During the destructive distillation of wood, an impure acid distils over; carbonate of soda is added to the distillate, and an acetate of soda formed, which is purified and distilled with sulphuric acid.

CHARACTERS.—A colourless liquid of pungent odour and taste: sp. gr. 1·044. It is volatile and, on evaporation, should leave no residue. Contains 28 per cent. of anhydrous acid.

ACIDUM ACETICUM DILUTUM—DILUTE ACETIC ACID.

PREPARATION.—By adding 1 part of acetic acid to 7 of distilled water. The sp. gr. is 1·006. Contains 3·6 per cent. of anhydrous acid.

ACETUM—VINEGAR.

Is an impure dilute acetic acid, derived from alcohol. In France it is made from wine, and is stronger than the English vinegar, which is obtained from a fermenting infusion of malt exposed freely to air. The sugar it contains is first changed into alcohol, which by further oxidation (under the influence of a fungus found in the solution) is transformed into acetic acid; thus—

$$C_2H_6O + O_2 \text{ becomes } C_2H_4O_2 + H_2O,$$

the acid being derived from the alcohol by the substitution of one atom of oxygen for two of hydrogen.

CHARACTERS AND TESTS.—Vinegar has a sp. gr. of 1·017 to 1·019, is usually brown in colour, and has a distinctive odour,

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due probably to a minute quantity of acetic ether: it contains 4·6 per cent. of anhydrous acetic acid. It is liable to become mouldy if exposed long to the air, and in order to prevent this, a little sulphuric acid is commonly added: $\frac{1}{1000}$ part by weight is allowed by law.

ABSORPTION AND ELIMINATION.—The dilute acid is readily absorbed by the stomach, and combines in the blood, to some extent, if not wholly, with soda salts to form acetate of soda; like other salts of vegetable acids, this is ultimately eliminated in the urine as a carbonate. The acetate of soda was one of the first salts with which the decomposition was verified by Wöhler (1824).

PHYSIOLOGICAL ACTION—*External.*—Glacial acetic acid is a caustic, and applied to the ordinary skin, causes redness, pain, and sometimes vesication or even inflammation of the cutis and subjacent tissue. The diluted acids exert a moderately irritant, or simply a cooling astringent effect, according to the degree of dilution, of continuance of application, friction, etc. Mucous membranes are blanched by it.

PHYSIOLOGICAL ACTION.—*Internal.*—Digestive System, etc.—Dilute acetic acid in moderate doses has a cooling eupeptic action. It diminishes thirst partly by causing a flow of alkaline saliva. In large quantity it lessens secretion of acid gastric juice, and so stops digestion and impairs nutrition.

The stronger acid, taken into the stomach, acts as an irritant poison, and has occasionally caused death; it induces burning sensations in the throat and stomach, and acute abdominal pain with tympanitic distension, tightness across the chest, and much anguish; the buccal mucous membrane is whitened, the tongue becomes dry, cold, and tremulous, nausea and vomiting occur, with hurried, laboured breathing, and quick, small pulse; the pupils are dilated; cold clammy perspirations cover the body; nervous tremor and sometimes convulsions have occurred.

Action on the Blood.—This is very similar to that of sulphuric acid. Heine (Virchow's Archiv, xli., 1867, p. 24) examined the effects of acetic acid brought into direct contact with the blood by injection, and came to the conclusion that

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the acid decomposes the hæmoglobin, expels oxygen from the corpuscles, coagulates their albuminous substance, together with the hæmatin, causes the passage of this latter into the serum, giving rise to the *lac-colour* of the blood. The red corpuscles become finely dotted in the centre, owing to the coagulation of the albumen. The blood remains fluid after only small doses, but is always coagulated by very large ones. After direct injection of the acid into the blood the temperature falls 2° C., though later on, when the destroyed corpuscles seem to act like a poisonous ferment, rigors and muscular tremor occur, with embolism, and septicæmia and consequent rise in temperature. The above-described discoloration of the blood (lac-colour) never takes place after the internal administration of the acid, as it does when injected into the veins.

SYNERGISTS.—Citric, tartaric, and other vegetable acids.

ANTAGONISTS — INCOMPATIBLES.—As an antidote in poisoning by caustic alkalies and lime, vinegar is to be recommended, since it is generally near at hand, and the compounds formed by it are not injurious. It is useful also in alcoholic intoxication. Alkalies and their carbonates are chemically incompatible with acetic acid.

THERAPEUTICAL ACTION.—*External.*—The glacial acid is sometimes employed as a *vesicant*, and is used in the acetum cantharidis as a solvent for the active principle of the Spanish fly, and to increase its efficacy.

Nævi—Corns—Warts.—These have been treated successfully with the strong acid, and warts are easily removed by a few applications of it.

Lupus.—In the erythematous form the glacial acid may be applied about twice weekly, with much advantage and without production of scarring.

For Frost-bite, vinegar applied with friction is a good external application.

Cancer.—A somewhat dilute acid (1 part acetic acid in 3 of water) has been used as a local injection into cancerous tissue, and Dr. Broadbent argued that since it dissolved cancer-cells outside the body, and could readily penetrate living tissues

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(not coagulating albumen), it might lead to local destruction and disintegration of malignant growths when brought into direct contact with them: about 30 min. were injected at a time, and some satisfactory results were reported (Med. Times, 1866 67). I have, however, seen harm done by it, and Heine's experiments show some danger in such injections. This method of treatment has not maintained its ground, and is now seldom practised.

Ringworm.—Acetic acid (1 part in 3) has been applied in this disorder, and with good results, but other remedies are more commonly used.

Psoriasis.—Acetic acid used locally promotes separation of the thick scales of psoriasis, and stimulates healthy action, just as a blister will sometimes do, but it causes much pain if the skin is fissured.

Hæmorrhage.—Syringing with vinegar is frequently used as an astringent and styptic remedy for bleeding from the nose, and sponging with it for parenchymatous hæmorrhage; in metrorrhagia it may be used by vaginal injection, or tampons may be soaked in it. These, however, irritate and become unpleasant in four to six hours.

Nocturnal Sweating.—The night-sweats which are so profuse and exhausting in the later stages of phthisis and in some conditions of debility, are often controlled by sponging the body with warm vinegar night and morning.

Spermatorrhœa.—Compresses soaked with vinegar and applied to the perineum at bed-time often cure this affection. Should soreness be produced, treatment must be omitted for a time.

Spinal Weakness.—In cases of aching and debility referred to the lower spine, and dependent probably on impaired power of the erector spinæ, I have seen much advantage from sponging the back with equal parts of spirit of wine and dilute acetic acid.

THERAPEUTICAL ACTION.—*Internal.*—**Scarlet Fever.**—Dilute acetic acid is used by some practitioners from the commencement of this fever in all cases. Freely diluted, it certainly makes a grateful refrigerant drink. Where the eruption is more or less suppressed, a teaspoonful of vinegar given in

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sweetened water every two to four hours for a few doses, is said to cause diaphoresis, and to assist in bringing out the rash: however this may be, sponging the body with hot vinegar and water twice or thrice daily is often useful.

Dr. J. Dougall specially recommends the aromatic glacial acetic acid impregnated with neroli, rosemary, etc.—1 dr. to the oz. of water is used for sponging, and some is volatilized in the sick room (B. M. J., ii., 1879).

Diarrhœa.—When this occurs in the course of phthisis, or hectic fever, it may sometimes be controlled by the internal administration of vinegar.

Obesity.—When vinegar is taken continuously for five to six weeks, it causes emaciation, and in cases of obesity was formerly used with the object of taking down superfluous fat. A wineglassful was given each morning, fasting, and again at bedtime, but serious consequences, such as phthisis, etc., having occasionally followed this treatment, it has fallen into disuse.

PREPARATIONS AND DOSE.—*Acidum aceticum glaciale:* not given internally. *Acidum aceticum:* used externally as a rubefacient, vesicant, and escharotic. *Acidum aceticum dilutum:* dose, 1 to 2 fl. dr., or more, well diluted. *Oxymel:* dose, 1 to 2 fl. dr. *Acetum* (vinegar): dose, 1 to 2 fl. dr.

ADULTERATIONS.—Sulphuric acid and metallic impurities taken up from metal vessels in which it has been kept.

ACIDUM CARBONICUM—CARBONIC ACID, CO_2, = 44 (*not officinal*).

This gas occurs in the atmosphere in the proportion of 2 to 6 parts in 10,000; the air contained in the interstices of arable land has more, and in some grottoes and natural hollows, communicating probably with ancient volcanoes, carbonic acid accumulates, so as to exert toxic effects. This is the case in the well-known Grotto del Cane at Naples, the Upas valley of Java, and in many parts of Auvergne and Vivarais ("estouffis"). The gas is contained also in all water in varying quantity,

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certain sparkling waters having a proportion of more than half their volume. It occurs in all the liquids of the organism, principally in the blood, but also, in less quantity, in the urine: in the former, it exists combined with alkali, chiefly soda, and also in a free state; in the latter Morin found a proportion of 20 cub. cent. to the litre: this was increased under administration of carbonated water, also after walking exercise: it was greatly diminished by free drinking of ordinary water. It originates in the chemical phenomena of combustion and nutrition which are constantly taking place in the tissues, and it readily passes by osmosis through the animal membranes.

PREPARATION.—By treating any carbonate—usually carbonate of lime—with dilute hydrochloric acid: the resulting gas is passed into water under pressure, and a solution is thus btained.

CHARACTERS.—A colourless inodorous gas of slightly sharp taste. It is soluble in its own volume of pure water at ordinary temperature and pressure—much more soluble under increased pressure and lowered temperature of the water. The solution gives an acid reaction, and is "sparkling" from rapid escape of gas. Carbonic acid is much more soluble in water containing *phosphates* than it is in pure water, and conversely, water containing the gas can dissolve and retain in solution, *carbonates* and *phosphates* of magnesia, lime, iron, etc., which pure water cannot. The sp. gr. of the gas is 1·526 (atmospheric air taken as 1). It is twenty-two times heavier than hydrogen.

ABSORPTION AND ELIMINATION.—Carbonic acid is easily absorbed by denuded surfaces, and by mucous and serous membranes. That it may be absorbed also through the unbroken skin is apparent from the systemic effects produced not only by carbonic acid baths in general, but by keeping separate limbs in an atmosphere of the gas whilst the respiratory organs are protected from it (Collard de Martigny). If taken in solution into the stomach, it is said to be absorbed, if the viscus be *empty*,—whilst if it be *full*, the gas is rejected by eructation and per anum as flatus (Lehmann). Up to a certain amount, it may be absorbed through the lungs by the blood. In any normal condition, the blood is never *saturated* with the gas, but is always

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ready to receive more as it is freshly formed in the tissues. It circulates partly dissolved by the serum and partly combined with alkaline salts. It is eliminated almost entirely by the lungs and the skin, but in small proportion by the kidneys; also by the large bowel.

PHYSIOLOGICAL ACTION.—*External.* — When carbonic acid gas, undiluted, is brought into contact with the skin, it causes some prickling and sense of warmth, with or without redness; this is said to be most marked about the perineum and scrotum—the latter contracts under its influence. To this effect succeeds a certain degree of anæsthesia (Rotureau) or analgesia, which, however, is not complete enough for operative purposes (Demarquay). In contact with mucous surfaces, or the exposed cutis vera, the effects are more marked, and more quickly produced. The oculo-nasal membrane is especially sensitive to a current of the gas, whilst the uterine membrane, and even wounded surfaces show the anæsthetic effect without much previous stimulation.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.** —When taken into the stomach, as it usually is, in aqueous solution, carbonic acid is refreshing and thirst-quenching. It somewhat increases the gastro-intestinal secretions, and excites their peristaltic action, but diminishes the sensibility of the mucous membrane. A moderate quantity improves appetite, but an over-dose lessens it. No such serious symptoms follow, however, as after inhalation of the gas by the lungs.

Respiratory System.—The gas is markedly more poisonous when inhaled than when taken in any other way. It hinders exhalation of the carbonic acid normally existing in the blood, and is itself absorbed in small quantity, thus inducing dyspnœa; a proportion of 10 per cent. in the air is irrespirable and fatal. The undiluted gas first excites irritation and sometimes spasmodic contraction of the glottis with consequent asphyxia (Wareing); in any case, and independently of such spasm, it soon arrests respiration. It has been thought that the gas is itself inert, and induces death only by preventing the due interchange of oxygen and carbonic acid in the lungs

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(Bichat, Regnault, etc.), but recent observations suggest that it is actively poisonous, since young mammals die by cardiac arrest, after two or three minutes in an atmosphere charged with it, whilst they live fifteen to twenty minutes in nitrogen or hydrogen (Paul Bert, Rabuteau), and the heart continues to beat in the latter case after respiration has ceased. The experiments of Collard de Martigny, Orfila, van Hasselt, and others, point to the same conclusion.

Circulatory System.—The effect of respired carbonic acid in preventing oxygenation of blood is quickly shown by the appearance of more or less cyanosis, with slow, laboured pulse, and ultimate arrest of heart-action. It does not, however, intimately combine with, and fix itself upon, the hæmoglobin, since this remains red and unreduced in an atmosphere even highly charged with carbonic acid, provided that a normal amount of oxygen is present also; whilst in animals dying deprived of oxygen, the blood is found black, hæmoglobin being completely reduced. The effects of the internal administration of the gas, or even its careful injection into the larger venous trunks, differ from those produced by its inhalation, and are such as slight stimulation of the heart-action, quickening of respiration, and increase of the peripheral circulation, with a slight prickling of skin and brief sense of exhilaration; this is often experienced from sparkling beer, wine, and even waters. Husemann remarks that experiments with "direct injection" of carbonic acid into the blood (Nysten, Demarquay) have not led to great results, on account of the smallness of the amount that can be injected without death occurring from the entrance of air into veins. Even small quantities thus injected cause muscular weakness, a symptom which only appears *late* in the inhalation of dilute carbonic acid gas.

Nervo-Muscular System.—The most marked effects of carbonic acid poisoning (from breathing the gas) are exerted upon the nervous system. An amount of 3 per 1,000 in the atmosphere of a room will cause throbbing headache, with fulness and tightness across the temples, and giddiness: more of the gas may induce fainting, muscular weakness, somnolence, or insensibility, coma, or convulsion.

Brown-Séquard taught that carbonic acid was a muscular excitant, because of the uterine contractions observed after

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injecting it into the vagina, the excitement induced by arterial injections of blood charged with carbonic acid, and the convulsions said to be caused by directing the injections towards the head. Cyon further taught that the cardiac arrest caused by this gas was due to excitement of the vagus, but more modern observation leads us to regard the gas rather as a sedative. I have already mentioned the local anæsthesia it can produce, and Leven always found in his experiments anæsthesia with slowing of respiration and circulation, and finally cardiac arrest—no convulsion. I should say with Rabuteau (p. 743) that in therapeutical doses it modifies sensibility, whilst in toxic quantity it abolishes at once the functions of nerve and muscle. On the organs of special sense, anæsthetic effects are preceded not only by prickling and warmth, but also by muscæ volitantes, tinnitus, and other phenomena connected with congestion. Herpin found that the gas, when diluted with 80 to 90 per cent. air, produced gradual anæsthesia without suffocation or pain.

Nutrition—Excretion.—The inhalation of carbonic acid modifies the processes of nutrition in a manner not yet understood: sugar has been found in the blood and liver of animals poisoned by it. More *diuresis* is caused by *carbonated*, than by ordinary water.

SYNERGISTS.—Alcohol, ether, and other hydro-carbons cause intoxication and produce anæsthesia somewhat similar in character.

ANTAGONISTS.—Oxygen and stimulants of the peripheral circulation.

THERAPEUTICAL ACTION.—*External.*—**Wounds, etc.**—Demarquay and Leconte found that atonic and gangrenous ulcers and diphtheritic wounds recovered under applications of carbonic acid gas when they had not yielded to other remedies. The cicatrization of wounds was also favoured by it, and when injected into the cellular tissue in cases of tenotomy, repair of tendons was said to be hastened by it, whilst by oxygen it was retarded. Good results in the same class of cases have been reported from Rehme, Nauheim, and other Spas where the gas is employed therapeutically (*r.* p. 214).

Vesical Catarrh, etc.—The pain, the muco-purulent discharge, and the irritability of bladder connected with this

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malady, may certainly be relieved by local injections of carbonic acid gas,—a method of treatment not, perhaps, so often used as it deserves to be. Dr. Johns, Sir James Simpson, Dr. Skinner, and others have reported much improvement in many severe and chronic cases (B. M. J., 1858; Med. Times, 1858–59). The gas is disengaged from a carbonate mixed with tartaric acid, and conveyed through a catheter, the bladder being previously washed out if possible. It is desirable to avoid over-distension of the viscus, either by using only a measured quantity (Skinner), or employing a double catheter (Johns). If too much be injected, there may be some burning pain, and afterwards drowsiness and sense of exhaustion, but these symptoms are temporary, and are, in most cases, not felt at all, whilst relief follows very quickly and lasts for a long time, suggesting that the gas is retained in the bladder for several hours before being absorbed: its use is commonly though not always followed by excretion of urine containing much mucus and oxalates.

The gas may be employed in almost all forms of irritability of the bladder, unless acute inflammation be present—if irritation be severe, it may be diluted with air.

Gout—Paralysis.—At Kissingen, baths containing carbonic acid gas are much used for these maladies. Dr. Parkin wrote strongly upon the value of carbonic acid in gout, but administered it in the complex form of a strong alkaline effervescent draught (Lancet, 1843).

Pelvic and Uterine Pain.—In many painful affections of the pelvic viscera, whether neuralgic, sympathetic, or even arising from organic disease, injection of carbonic acid into the vagina acts as an anæsthetic and sedative; but as it sometimes increases irritation for a time, it is not suited for cases with acute congestion. Dewees, de Rossi (1834–35), and other physicians of still earlier date, used the gas with advantage, and Sir James Simpson records ample and favourable experience with it in dysmenorrhœa, etc. It gives relief even to the pain of cancer, but seems to have sometimes caused giddiness, headache, and weakness (Bernard, Med. Times, i., 1858, p. 380). The warm baths at Driburg (Westphalia), which are highly charged with carbonic acid, are said to be useful in cases of anæmic

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amenorrhœa and leucorrhœa, and to exert a favourable influence upon utero-gestation, so that healthier children are born after their use. They have been described as "champagne baths," and exert a stimulating effect upon the whole surface, especially upon the genitals; they also induce a free secretion of urine. They relieve partial or hysterical paralysis connected with pelvic irritation, but are contra-indicated in acute congestion and in epilepsy.

At the "sool-sprudel" of Kissingen, especially when heated or when agitated by jet or wave, so large an amount of gas passes into the air as to cause sometimes giddiness, dyspnœa, etc. At Rehme the baths are used "still" with better result, especially in certain forms of paralysis and spinal irritation. At this place, also, gas-baths are given, but Dr. Braun does not attach much value to them unless in cases of atonic ulceration, and in irregular menstruation from atony of uterus.

Scanzoni injected carbonic acid gas into the vagina or uterus to induce premature labour, and with successful results (Brit. and For. Rev., ii., 1856), but the method is not desirable on account of some risk of the gas entering a large vein. Dr. Tyler Smith has pointed out that abortion occurs where pregnant women are exposed to the poisonous influence of the gas, but this may be secondary to the asphyxia produced.

Phthisis. — Inhalations of carbonic acid are indicated in certain irritative forms of pulmonary phthisis, as likely to diminish active erethism and slow the progress of destruction (Withering, Beddoes, etc.). The air of stables is said to be beneficial partly for this reason.

Pharyngitis—Granular Angina.—Chronic cases of these maladies and of laryngitis are treated at Ems by inhalation of the gas, and at Vichy by the carbonic acid douche.

Chronic Bronchitis—Asthma.—Simpson states that he has often seen benefit from inhalations containing 5 to 10 per cent. of carbonic acid in these maladies, and in chronic cough. Such inhalations are much better tolerated than is commonly thought (Skinner), and they are practised at St. Moritz, at Ems, and elsewhere, but Dr. C. T. Williams speaks of danger arising from them, on account of difficulty in regulating the dose (Lancet, ii., 1873, p. 516). The relief given in asthmatic attacks

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by the fumes of nitre paper has been attributed to the carbonic acid contained in them, and it is a matter of clinical experience that asthmatic patients frequently breathe better in a crowded part of a town—where the amount of this gas is greater—than they do in the pure air of the country.

Vomiting—Dyspepsia.—When the gastric mucous membrane is morbidly sensitive and irritable, carbonic acid gas dissolved in water is an excellent sedative, and in uncomplicated cases is sufficient to relieve vomiting. It is commonly given in combination with an alkali, as in the ordinary effervescent mixture, or in the waters of Homburg, Carlsbad, Vichy, etc., but water charged with the gas *only*, often answers exceedingly well, and has sometimes cured intense gastric irritation (chronic in character with great nerve-depression) after the failure of treatment at celebrated Spas.

There are other virtues attributed to carbonic acid, which are not so well ascertained. Thus, Dr. Parkin and Dr. Ritson argued that the freedom of many ports from *cholera* was traceable to the increased amount of carbonic acid in the atmosphere of their coal works and wharves! (Lancet, ii., 1848).

ACIDUM CITRICUM—CITRIC ACID,

$H_2C_6H_5O_7$, H_2O, = 200.

This acid occurs in many plants and acidulous fruits, especially in those belonging to the Aurantiaceæ or orange family, and is commonly obtained from lemon or lime-juice (*cf.* vol. i., p. 177).

PREPARATION.—The lemon-juice is first boiled, in order to coagulate the albuminous substances, and then saturated, while hot, with chalk, so that *citrate* of calcium is formed; this is washed with hot water (it would dissolve in cold), and then treated with sulphuric acid, which forms *sulphate* of calcium (to be removed by filtration), and the solution concentrated at a moderate temperature, to allow citric acid to crystallize out.

(1) $2H_2C_6H_5O_7 + 3CaCO_3 = Ca_32C_6H_5O_7 + 3H_2O + 3CO_2$.

(2) $Ca_32C_6H_5O_7 + 3H_2SO_4 = 3CaSO_4 + 2H_3C_6H_5O_7$.

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Good lemon-juice yields from 2½ to 10 per cent. of citric acid, the quantity varying because it decreases in proportion to the time that the lemons are kept, and it may quite disappear, separating into glucose, carbonic anhydride, and some acetic acid.

CHARACTERS.—Occurs in colourless crystals of which the right rhombic prism is the primary form; they are permanent in dry, but become moist in a damp atmosphere; sp. gr. 1·6; taste strongly acid, and almost caustic, but in weak solutions only agreeably acid and refreshing; very soluble in water and in glycerine, less so in spirit, and not at all in ether. Seventeen grains of citric acid (equivalent to about ½ oz. lemon-juice) saturate 13 of magnesian carbonate, 15 of the ammoniacal, 20 of the soda, 25 of the potash salt; somewhat less than these quantities are commonly used. A small proportion of citric acid prevents some chemical decompositions, *e.g.*, in the syrupus ferri iodidi.

ABSORPTION AND ELIMINATION.—Citric acid is readily absorbed by the stomach and intestines, and is excreted in part by the kidneys in the urine in combination with bases. The greater part is oxidized in the system, forming carbonic acid and water. Buchheim and Pietrowski found none in the urine after 30 to 60-gramme doses. According to Bence Jones and Eylandt, the acidity of urine is increased by citric, as it is by tartaric acid, and a deposit of free uric acid may be induced by it.

PHYSIOLOGICAL ACTION.—Concentrated solutions do not irritate the skin, hence Mitscherlich and others conclude citric to be *less irritant* than tartaric acid, but abraded surfaces and mucous membranes become irritated by it; and although it is not known to have caused death in man, Husemann considers it, from its effects on animals, to be *more poisonous* than tartaric acid. Eight to fifteen grammes destroy large rabbits within one hour, with cramp, opisthotonos, dyspnœa, weakened heart-action, and general prostration. Bobrik observed tremor and cramp, difficulty of breathing, slowing of pulse, and lowering of temperature (in rabbits). On dissection the blood was found fluid, and the gastro-intestinal mucous membrane inflamed and ecchymosed.

SYNERGISTS.—Tartaric and other vegetable acids.

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INCOMPATIBLES.—Alkaline carbonates, acetates, and sulphurets; tartrate of potash.

THERAPEUTICAL ACTION.—*External.*—**Cancer, etc.**—A solution of citric acid—60 to 90 gr. in 8 oz. water—will sometimes markedly relieve the pain of cancerous ulceration. I have verified this fact in cancer of the tongue, of the breast, and of other parts, without being able to explain it. It is not generally known, but has been several times recorded, *e.g.*, by Brandini, by Denny (Lancet, i., 1866), and Barclay (B. M. J., i., 1866). Chronic cases of psoriasis and eczema, especially in gouty subjects, are relieved by the daily use of slices of fresh lemon.

Pruritus.—A hot lotion containing citric acid is often serviceable in relieving itching.

THERAPEUTICAL ACTION.—*Internal.*—**Irritability of Stomach.**—In cases of dyspepsia, marked especially by local discomfort, much thirst, and tendency to nausea or sickness, effervescing alkaline citrates are often both grateful and remedial. Citric acid, or its compounds, are good refrigerants, and allay thirst in cases of fever.

Rheumatism.—To the observations already made on this subject (vol. i., p. 178), I have to add that citric acid is specially indicated in those perhaps exceptional cases of rheumatism when the urine is alkaline, either from some peculiarity in the attack or from too prolonged use of alkali, and when depression is a marked symptom. In such a condition, occurring together with bronchitis and valvular disease in a gouty subject, I have seen lemon-juice given with some alcohol relieve after failure of alkalies, iodides, etc.

In Scorbutic Dysentery, lemon-juice was commended by Sir William Ferguson (Edin. Med. Journ., Oct., 1837), and for **ammoniacal urine** by Dr. Bence Jones. I have used it in the latter condition, and found it serviceable.

PREPARATIONS AND DOSE.—*Acidum citricum*: dose, 10 to 30 gr., diluted and sweetened.

ADULTERATION.—Sometimes tartaric or sulphuric acid.

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ACIDUM HYDROCHLORICUM—HYDROCHLORIC ACID, HCl, = 36·5,

Is found in the animal kingdom, in the gastric juice of mammals and fishes; in the vegetable kingdom (Isatis tinctoria); in the mineral kingdom combined with metals, earths, and alkalies (sodium chloride, etc.), and in the springs of volcanic regions. The hydrochloric or muriatic acid of the Pharmacopœia is a solution of hydrochloric acid gas in water, to the extent of nearly 32 per cent. by weight.

PREPARATION.—Being a volatile acid, it can be prepared from any chloride by distillation with the less volatile sulphuric acid—common salt is usually employed, and hence the acid has been termed "spirit of salt," and "marine acid." When salt is mixed with dilute sulphuric acid, sulphate of sodium is formed, and free hydrochloric acid distils over into a receiver containing water, in which it is very soluble.

$$NaCl + H_2SO_4 = NaHSO_4 + HCl.$$

CHARACTERS AND TESTS.—The pure acid is colourless, but the commercial acid yellowish, owing to the presence of some organic matter, as cork, or of ferric chloride, from the iron stills in which it is prepared. It has a very sour taste and a suffocating odour, giving off white fumes when exposed to the air, from escape of the acid gas, and its union with the moisture of the atmosphere. A rod dipped in liquor ammoniæ and held over a bottle of the acid forms dense white fumes of sal ammoniac; nitrate of silver produces a curdy white precipitate of chloride of silver, insoluble in nitric acid, soluble in ammonia, and becoming dark on exposure to light. The sp. gr. of the acid varies with its strength, the strongest having a density of 1·21. The application of heat should dissipate it without residue, implying the absence of lead and solid impurities. It may contain sulphurous acid, which would be detected by action on lead-paper.

ABSORPTION AND ELIMINATION.—The mineral acids in moderately strong solution may be absorbed through the skin,

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as proved, for instance, by the physiological effects produced by the nitro-muriatic bath. Dilute hydrochloric acid, taken internally, is absorbed by the stomach, probably unchanged, but any that passes into the intestines would have time to combine in part with soda, and form chloride of sodium before entering the capillaries. It has been said that any acid introduced as such into the blood becomes so closely combined with the albumen as to reach the emunctories before being wholly combined with alkali, but if so, the acid is not traceable by test paper (F. Walter, Die Wirkung der Saüren, etc., Archiv f. Exper. Pathol., April, 1877). According to this careful observer an acid reaction of the blood is incompatible with life. Elimination is effected mainly by the urine, the quantity and the acidity of this excretion being usually increased.

PHYSIOLOGICAL ACTION. — *External.* — Strong hydrochloric, like other mineral acids, acts with energy on animal tissue, abstracting water, and combining with potash, soda, and lime bases: it does not penetrate so deeply as sulphuric or nitric acid, but produces a white stain, and this part afterwards sloughs. On the digestive tract, strong doses have a similar action, and excite gastro-enteritis. Fermentation of any kind is arrested by this acid. Dr. John Dougall considers it, when diluted with twenty parts of water, "the cheapest, most easily used, and most effective non-aerial disinfectant," especially for typhoid excreta and the bed and body-clothes of persons with infectious disease (B. M. J., ii., 1879).

PHYSIOLOGICAL ACTION.— *Internal.*—**Digestive System.** —Administered in moderate dose and dilute solution, hydrochloric acid has two main effects—(1), it augments the acidity of the gastric juice, and (2), after absorption, it gives rise to extra-formation of chloride of sodium. It is first eupeptic, and then assists hæmatosis; it also aids the solution of useful substances which would be otherwise inert, such as phosphate and carbonate of lime, metallic iron, oxides, etc. (Rabuteau).

The augmented acidity of the gastric juice, as a rule and within certain limits, improves the digestive power and increases formation of peptones; it is accompanied by greater secretion of saliva, and a sense of warmth at the stomach, but if

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carried to excess causes irritation. A great part of the interest connected with the study of this acid depends upon the question whether it really forms an integral part of the normal secretion of the gastric glands, and there is certainly a large amount of evidence in the affirmative. Besides the older observations of Prout (Phil. Trans., 1824), of Lassaigne (Journ. de Chim., t. x.), and others, we have the more recent analyses of Schmidt (Die Verdauungssäfte, 1852), and of Gautier (Chimie Appliquée, 1874), who even calculate the proportion of free hydrochloric acid as 3·05 per 1,000. It is not denied that lactic, acetic, and butyric acids may also be found in the gastric juice, as described by Cl. Bernard, Lehmann, and other eminent authorities, but it is almost certain that they result from chemical changes during the digestion of foreign substances. Enderlin, examining the quite fresh gastric secretion of an executed criminal, could find no trace of lactic acid, nor could any *organic* acid act on fluoride of calcium as gastric juice does (Melsens). Further, Rabuteau claims to have demonstrated by an original process the existence of hydrochloric acid in the secretion of fishes (Comptes Rendues, 1873) and of dogs (Éléments de Thérap., 1875, p. 429). After a fast of twenty-four hours he gave to two animals some bits of tendon, and about an hour afterwards divided their medulla. The very acid gastric juice was collected, filtered, saturated with pure quinine, evaporated, and divided into two portions. One part was exhausted by benzine, which can dissolve hydrochlorate and lactate of quinine (though not alkaline chlorides), and on evaporating the benzine, hydrochlorate of quinine was easily recognized. The other part was treated by amylic alcohol, which was then evaporated, and the residue treated by chloroform, which took up a salt proved to be solely hydrochlorate of quinine without trace of lactate. He estimated the quantity of free acid at 2·5 per 1,000—not very different from the results of Schmidt, and we may fairly presume that the acid is derived from the chloride of sodium circulating in the blood. Lactate of soda is not likely to circulate, inasmuch as it would, very soon after absorption, be changed into bicarbonate. "A free acid always exists in gastric juice, which is usually hydrochloric, rarely lactic acid alone, not unfrequently a mixture of both acids" (McKendrick's Physiology, 1878).

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If, then, hydrochloric acid be the normal acid of the gastric juice, it would seem to be the one most easily assimilated by the stomach, and should be preferred, as a rule, when acid is indicated. It is scarcely necessary to state that if administered undiluted this acid causes irritant poisoning with symptoms similar to those described fully under sulphuric acid.

Circulatory System.—As the blood and lymph, and almost all the secretions of the body have an alkaline reaction, it becomes interesting and important to inquire what effect is produced upon such alkalinity by the administration of acids. Some observers, as Eylandt, Wilde, and Gaethgens have concluded that any altered relation of acids and bases within the body occurs, if at all, within very narrow limits.[1] Hofmann held that an excess of free acid can pass through the blood to the urine, but this is probably incorrect. Miguel, after giving sulphuric acid, found the *alkaline salts* of the urine increased in amount—implying that the acid combined with alkali in the blood, and thus removed from that fluid for excretion an unusual proportion of such alkali. Salkowski arrived at a similar conclusion, and Lassar asserted, from analyses of blood, that its alkalinity was much lowered under the use of acids. But the estimation of urinary ingredients does not give a satisfactory answer to the question, and alkalimetry, as applied to the blood, is exceedingly difficult, hence another and an ingenious method of analysis has been adopted by F. Walter (op. cit., April, 1875). Starting from the highly probable supposition that the carbonic acid contained in the blood must be almost wholly in combination with alkalies, and that its amount must therefore be proportional to, and be an index of, the amount of alkali contained in that liquid, he analyzed the gas-contents of blood withdrawn from animals under acid-treatment, as compared with that of animals in a normal condition. Most of his experiments were made with hydrochloric acid, because it required less water for dilution than other acids. From 1 to 3 grammes of acid were given diluted, in three doses, by the stomach tube, in the course of twenty to forty hours. The blood was drawn from veins after decided symptoms of acid-poisoning had set in, and when

[1] Souligoux attaches much importance to it, as altering galvanic reactions within the system.

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compared with normal blood it showed a remarkable *lessening* of the carbonic acid, and (by inference) of combined alkalies. This was especially the case in rabbits (herbivora). Whilst normal rabbit-blood showed an average percentage of 25 volumes CO_2, that drawn after 1·22 grammes of acid gave 16, and after 2·44 grammes of acid, only 3 volumes of the gas; this blood was dark, and coagulated with difficulty, but was decidedly, though weakly, alkaline in reaction. In dogs (carnivora) the difference was not so great, but a diminution of about 10 per cent. in the amount of CO_2 occurred under the influence of hydrochloric acid. This curious difference between the effects of the acid on the two classes of animals was first pointed out by Salkowski, and it was found that dogs have a certain immunity as to the general symptoms of acid-poisoning, so that they can take much larger doses than the herbivora without ill results. (This has been accounted for by increased formation of ammonia compounds in the latter class of animals under the influence of the acid, causing its neutralization, to some extent.) The experiments of Walter prove, however, that it is possible, by means of the internal administration of acids, to withdraw alkalies from the vital fluids, and this to such an extent as even to cause death from their deprivation.

With regard to the influence of hydrochloric acid on the general circulation, it was noticed by early observers—Boerhaave and others—that even moderate doses accelerate the pulse and cause flushing of the face; and full doses produce some excitement of brain-function, so that the symptoms have been compared to those caused by alcohol (Deutsch). Bobrick took 18 min. diluted with 5 oz. of water, and within half an hour noted an increase of pulse by six beats. This continued for an hour, but was succeeded by a fall of four beats below the normal frequency. He noticed excitement of similar character after internal and external applications of the acid to frogs, and concluded that it was produced through the nervous system, for it did not appear after destruction of the nerve-centres.

Respiratory System—Toxic Action.—F. Walter found that in different animals of the same species, the action of the acid was different; from 7 to 8 grammes of hydrochloric acid per

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kilogramme of body-weight might be given to a rabbit in one day without necessarily serious result, but if the proportion of 9 grammes in the same period were exceeded, death certainly followed within a few hours. The first symptom of poisoning was an increase of frequency in respiration; then the separate breath-movements became deeper and more laborious, with violent heaving of the thorax; the heart beat so quickly that the pulse could not be counted; the animal lost power of moving, and lay quiet on the side for a quarter of an hour before death. The respiration then lost its dyspnœal character, and grew superficial and weaker as collapse set in, and the heart-action ceased a few moments after the breathing (loc. cit., p. 157). Post-mortem inspection revealed no sufficient change in the organism to account for these symptoms; sometimes, it is true, erosion of the gastric membrane occurred, but the course of the poisoning was not altered in such cases, and therefore it could not be dependent on such erosion: a different concentration of solution, whether 4 or 8 per cent., made no difference in the symptoms; the blood was only so far altered that it coagulated more slowly than usual. It was not found acid in reaction. Hence apparently neutralization of alkali, or withdrawal of some portion of alkali from the blood and tissues, was the cause of death; and this hypothesis was remarkably confirmed by the results of injection of an alkali into the blood-current after full and toxic doses of acid had been given by the stomach. A rabbit that had received more than 6 grammes of hydrochloric acid in three days—three times as much as would kill it—together with 0·2 gramme carbonate of soda injected under the skin with each dose, recovered without loss of appetite or any symptom of poisoning. Another animal received more than 2 grammes of acid, and just when the symptoms indicated the near approach of death 0·5 gramme of soda carbonate was injected into the jugular vein; within ten minutes the strong thoracic movements subsided, the heart-action grew slower and stronger, the animal sat up and began to eat, and in an hour's time seemed quite restored. This direct antidotal action of injected alkali is very striking.

It would seem that the result of diminished alkali in the blood is first a stimulation and then a palsy of the respiratory

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centre, through which death may be induced. The dyspnœa is not connected with altered heart-action, and the paralysis of respiration must be distinguished from that of asphyxia, for the oxygen contained in the blood remains unchanged.

SYNERGISTS.—As refrigerant, tonic, and astringent, the other acids; as tonic and digestive, bitters, and also pepsine and possibly pancreatine.

INCOMPATIBLES.—Alkalies and bases, salts of silver especially. To neutralize irritant poisonous doses of acid, the alkali should be given in mucilaginous or albuminous liquids.

THERAPEUTICAL ACTION.—*External.*—**Stomatitis, etc.**—In inflammation, with patches of ulceration about the mucous membrane of the mouth and gums, hydrochloric acid, diluted with an equal part of glycerine, and applied to the sloughing spots will induce healthy action. In mercurial stomatitis, and in the aphthous conditions that occur in children, or during advanced disease, lotions containing 1 part of acid in 10 of rose-water, either alone or with chlorate of potash and glycerine, are very serviceable. The acid is also valuable given *internally* in such cases. To avoid possible injury to the teeth, plain or alkalized water should be used immediately afterwards.

Cynanche Maligna Ulcerosa.—In all forms of ulcerative sore throat, whether scarlatinal or otherwise, but especially when sloughing is present, and when there is marked general asthenia, hydrochloric acid is indicated as well locally as internally. It may be applied with a brush (1 part in 15 of liquid) or in gargle (2 dr. to 8 oz.). In gangrenous or "putrid" sore throat, the nearly pure acid may be carefully and lightly pencilled over the affected part.

Diphtheria.—Bretonneau recommended the application of the strong acid mixed only with a little honey to the false membranes and adjacent tissues, and this has sometimes arrested the local progress of the malady; but, on the other hand, it has sometimes done harm by exciting irritation, which has favoured the development of membrane. A weaker solution, such as the dilute acid of the Pharmacopœia (1 in 3¼), is to be preferred, and much advantage has been traced to it (Dr. Heslop, Med.

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Times, i., 1858, p. 612). A *weaker* gargle (1 or 2 dr. in 8 oz.), as above mentioned, may be used if the conditions admit.

THERAPEUTICAL ACTION. — *Internal.* — Dyspepsia. — There are two varieties of indigestion in which hydrochloric acid is especially indicated—the so-called "atonic" form, and the "acid" form—but the mode of its use is somewhat different for each.

Atonic dyspepsia occurs either in connection with general weakness or impaired hygienic conditions—for instance, in overworked factory girls, seamstresses, etc.,—or in well-fed persons who tax their stomach with too much nitrogenous food whilst leading a sedentary life. The secretion of gastric juice is but scanty, and the patient suffers from weight and heaviness after food, from general oppression, and other signs of unfinished digestion. One indication for the treatment of such a condition is to supply additional acid to the gastric secretion; but, as we have reason to believe that adding such acid *before* a meal will check the formation of the naturally acid though scanty gastric juice, it is better to allow this to do what it can, and to prescribe our medicinal acid shortly *after* food has been taken, with the object of assisting nature, and not interfering unduly.[1]

In cases of "acid" dyspepsia, the patient suffers rather from heartburn and regurgitation of sour fluid, connected either with hyper-secretion from the gastric glands, or abnormal fermentation of starchy, saccharine, or fatty food. It is true that the symptoms may often be relieved by soda, but in many cases, more permanent relief will be given by dilute hydrochloric acid administered about half an hour before a meal. This will lessen the amount of the natural secretion, and will check fermentation.

It is only recently that this important distinction as to the *time* of taking an acid with reference to food has been recognized; many writers, Nothnagel for instance, are satisfied with recommending its use always before meals, and certainly if it

[1] Manassein showed that in dogs made anæmic by blood-letting, the normal proportion of acid and pepsine was altered, and in such animals an addition of artificial acid to the gastric juice is, *ceteris paribus*, more effective than in the healthy (Virchow's Archiv, lv., p. 451).

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be given after food, in cases of *pyrosis or water-brash*, it will aggravate the mischief; these are the true cases in which its use is indicated *before* meals, when it exerts an astringent action. It is contra-indicated in acute inflammatory, and also in organic disease; and in any case its use should not be continued too long, or the digestive property of the gastric juice will be impaired.

Headache, especially felt in the temple and the brow, and marked giddiness are often connected with the dyspepsia above described, and are relieved by hydrochloric acid.

Diarrhœa.—In this complaint, hydrochloric is often preferred to other acids, not because it has a more energetic effect than, *e.g.*, sulphuric acid, but because it is better borne by the stomach. It is most reliable in cases that are due to abnormal fermentation in the bowels, with formation of lactic acid, as in what is called summer diarrhœa and gastric catarrh of infants; there are, however, many other remedies for this condition which must be considered better than the acid.

Fevers.—In typhoid or "low" fever, hydrochloric acid had, at one time, a high reputation; it was said to moderate the pyrexia, to limit the alteration of the blood, and to directly influence the morbid process. We scarcely expect so much now, but still there is reason to think that a judicious use of this acid may favour the assimilation of food, if it do not exert antiseptic influence. According to the investigations of Manassëin, with the gastric juice of fever patients, it is not *pepsine* that is deficient but *acid*, and this deficiency may be supplied for a time by the artificial acid, which then much aids the impaired digestion. It matters little whether we say with this observer, and with Chambers, that we supply deficient acid, or with Richardson, that we neutralize by it super-abundant alkali formed during fever. Chambers records an emphatic opinion as to its value, after a fairly extensive use of it at St. Mary's Hospital, in "low" fever, apparently typhus and typhoid. The treatment by hydrochloric acid was more successful than by any other method, but we must add that he conjoined with the former, strict attention to *nourishment*, giving milk and beef-tea regularly every two hours, day and night (Med. Times, 1858; Med.-Chir. Rev., ii., 1863). Henderson has reported on its

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value during an epidemic at Shanghai (Med. Times, i., 1863). On the other hand, Dr. G. Johnson is satisfied with the far better progress made by his typhoid patients in King's College Hospital since he *omitted* wholly mineral acid from their treatment. He finds, especially, that diarrhœa is less troublesome, and considers that acids irritate the bowels, just as bread or meat would do (B. M. J., i., 1875). I cannot think Dr. Johnson's reasoning very conclusive, though his facts are of course to be accepted. I think the acid sometimes useful, and if well diluted the doses required will not irritate the bowels. It may be given as a refrigerant drink in lemonade, or mixed with essence of meat so as to aid assimilation.

Scarlet Fever.—There is also evidence as to the value of hydrochloric acid in scarlatina. Osborne records a prolonged experience in its favour (Lancet, ii., 1862), and more recently Egbert (Pennsylvania) has quoted nearly 300 cases, all treated by a mixture containing this acid with chlorate of potash (Ranking, i., 1873). He gave about 8 min. of acid with 20 gr. of chlorate every two hours to a child of six, and more or less than this according to age. Occasionally Tinct. camph. co. was added to relieve restlessness; no applications were made to the throat, unless sometimes ice externally; only one death occurred. Of course it may be said that fevers tend to get well, and will do so under any treatment, but yet these results deserve careful attention. I myself constantly use hydrochloric acid internally and locally in cases of scarlet fever where there is marked general asthenia with dark ill-developed rash, and tendency to sloughing in the fauces (*v.* Chlorate of Potash).

Variola.—Dr. McDonald advocates the treatment of small-pox, both internally and externally, by this acid. He uses a lotion containing ʒss. ad ℥x. liq., and finds it considerably relieve the cutaneous itching and irritation.

Urinary Deposits.—In oxaluria, Dr. Prout long ago recommended hydrochloric acid, and its use is especially indicated for the impaired digestive power, and the anxious and depressed mental condition usually connected with the malady (*v.* p. 254). It may be given *before* meals with a bitter, such as nux vomica or chirata, and continued till urates begin

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to appear in excess in the renal secretion. In cystic oxide and phosphatic deposits with alkaline urine, it is also useful, and has sometimes been injected into the bladder for its local effect (♏ij. ad ℥iv. Aq.).

Gout.—Dr. Duncan recommended this acid as a preventive of the undue formation of lithic acid (Dub. Quart. Journ., May, 1865) by its aiding assimilation; hence it should be serviceable in chronic gout, but such a view has not been supported by the experience of others, and, as a rule, gouty subjects are very intolerant of any acid treatment.

There are several other disorders in which hydrochloric acid is sometimes, though not generally, used, but in which its good influence on the digestive tract may fairly be expected to relieve.

Pneumonia.—Traube states that he has found it useful in that form of pneumonia which sets in with much biliary disturbance — nausea, coated tongue, gastric catarrh, and diarrhœa.

Eczema.—Mr. Erichsen has published cases illustrating its value in chronic eczema (Lond. Med. Gaz., 1846, p. 198), but in this, and in hepatic disorder, its value is better shown when in combination with nitric acid.

Syphilis.—The former reputation of this acid as a cure for syphilis (Med. Quart. Rev., 1835) in Vienna, need be mentioned only as an historical fact (Nothnagel). The aqua regia may, however, prove of service in chronic cachectic conditions.

PREPARATIONS AND DOSE. — *Acidum hydrochloricum dilutum:* dose, 10 to 30 min. freely diluted. *The strong acid,* given internally in an undiluted form, is an irritant poison.

ADULTERATIONS.—Sulphurous and sulphuric acids, chlorine, and iron. The commercial acid is often coloured from the presence of iron impurities.

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ACIDUM NITRO-HYDROCHLORICUM DILUTUM —DILUTE NITRO-HYDROCHLORIC ACID— AQUA REGIA.

PREPARATION.—By mixing 3 parts of nitric, with 4 of hydrochloric acid, and afterwards 25 of distilled water: the strong acids, *undiluted*, are left to act upon each other for twenty-four hours to ensure complete decomposition and the full development of free chlorine.

$$2HNO_3 + 6HCl = 4H_2O + 2NO + 3Cl_2$$

At the same time two other compounds are formed—chloronitrous and chloronitric gas. If the acids be diluted *before* being mixed, the same reaction occurs, but requires several days for completion.

CHARACTERS AND TEST.—A colourless or yellowish liquid, with the odour of chlorine, volatile, and easily decomposed by light; sp. gr. 1·074. It has the power of dissolving gold, the king of metals—hence its old name, "aqua regia."

PHYSIOLOGICAL ACTION.—In its full strength this acid is irritant and corrosive; in moderate doses it has an alterative tonic action; it stimulates the glandular system, and is apt to cause salivation and also an increased flow of bile. Its actual chemical composition is not thoroughly known, and its difference in action from the other and simpler mineral acids has not yet been verified.

THERAPEUTICAL ACTION.—It is useful in many of the diseases mentioned under nitric acid, but seems to possess exceptional power to influence the liver and glandular structures of the alimentary canal.

Hepatic Disorder.—In hepatitis, not so much in the acute as in the chronic form of the malady, which usually ends in enlargement and induration, it has been praised by good authorities. Sir R. Martin strongly recommends its application by means of a bath, putting about 1½ oz. of acid to each gallon of water (*v.* Preparations). Two gallons represent an average quantity for a foot-bath, which should be used warm, and whilst

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the feet are immersed, the inner side of the limbs and the regions of liver and spleen should be sponged alternately for ten to fifteen minutes altogether. Martin recommended this bath morning and evening, but I have usually found an evening bath sufficient, and have seen excellent results from it; generally it has regulated the action of the bowels, and even produced laxative effects. Some patients are nauseated and weakened by its use, though they receive benefit: it requires watching, and smaller quantities of the acid should be tried first in delicate subjects. If it does not relax the bowels, an aperient should be taken occasionally during the course of the baths.

In hepatic torpor, or chronic catarrhal jaundice, if no inflammation be present, and in *chronic dysentery* with hepatic congestion, this form of bath is also valuable, and may be conjoined with the internal exhibition of the acid: even in *cirrhosis* and the consequent dropsy, benefit has been derived from this treatment.

Syphilis.—In the later stages of syphilitic cachexia, when the blood-condition is impaired, and elimination by the liver and skin is often inefficient, the acid used internally and in the form of bath has been recommended: a spare but nutritious diet should be enjoined in these cases.

Rachitis.—Attention has been drawn by Mr. Brodhurst to the value of nitro-hydrochloric acid baths in rickets (Lancet, ii., 1868); they should be conjoined with hygienic treatment, iron, and cod-liver oil.

Chronic Bronchitis.—When the expectoration is profuse and semi-purulent, sponging of chest and trunk with the acid solution already mentioned is said to give much relief (Dr. Waring, op. cit., p. 443).

Acne Rosacea.—A lotion containing the dilute acid, 1 or 2 dr. to 8 oz. of rose-water, is sometimes a useful stimulant to the affected part, and an acid foot-bath tends to relieve the internal congestions with which the disorder is generally associated.

Oxaluria.—This is, in most cases, dependent on some fault in primary digestion (I have known it produced apparently by continued use of a drinking water containing much lime), besides the renal symptoms, malaise, depression, and hypochondriacal feelings accompany the malady. Relief may be

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given by the mineral acids conjoined with attention to diet and drinking water; and of the different acids the nitro-hydrochloric seems to be the best, as originally stated by Dr. Prout (Stomach Disease, p. 73); he advised its continuance for a few weeks at a time, or until lithates appeared in the urine. Deposits of cystine are relieved by the same treatment.

Sciatica—Rheumatism.—In the great majority of these cases, an alkaline rather than an acid treatment is indicated, but when they occur in connection with oxaluria the acid should be given (Fuller). In rheumatic gout in cachectic subjects it is also serviceable.

Dyspepsia.—In dyspepsia or "apepsia," connected with deficient action of the intestinal glands, and accompanied with a chronic looseness of the bowels, the acid has given very good results, used in the manner directed under hydrochloric acid.

PREPARATIONS AND DOSE.—*Acidum nitro-hydrochloricum dilutum:* dose, 5 to 20 min., freely diluted (it is liable to injure the teeth; they should therefore be cleansed with an alkaline wash or plain water).

Bath.—As a matter of convenience the bath may be prepared with six fluid ounces of the *dilute* nitro-hydrochloric acid added to each gallon of water in a wooden or porcelain vessel, but the more active formula of Sir R. Martin is the following:—Acid. nit. fort. ʒij., Acid. hydrochloric. fort. ʒiij.; mix and allow to remain together for at least twelve hours; afterwards add 5 oz. of water. Of this mixture 3 oz. should be used for each gallon of water: two gallons are an average quantity for a foot-bath. The bath may be kept in use for several days by adding ½ oz. of acid solution and 1 pint of water each time to compensate for evaporation, warming only as much as is necessary (96° to 98° F.). The towels and sponges used should be kept in cold water during the intervals.

ADULTERATIONS. — Chiefly sulphuric and hydrochloric acids.

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ACIDUM HYDROCYANICUM DILUTUM—DILUTED HYDROCYANIC ACID, HCN or HCy, = 27.

A solution in water containing 2 per cent. by weight of the anhydrous acid (Scheele's acid contains 4 to 5 per cent., Vauquelin's 3·3 per cent.)

Amygdalin and emulsin, from which the acid is developed, exist together in many plants; in the leaves of the cherry-laurel, the kernels of the peach, almond, cherry, etc. In the mineral kingdom the acid is found in combination as cyanate and cyanide; it occurs also in various animal secretions, and may be obtained by heating nitrogenized organic matter in contact with a base. Scheele discovered the acid in 1782, and is said to have been accidentally poisoned by it.

PREPARATION.—By distilling, with gentle heat, a mixture of ferrocyanide of potassium (yellow prussiate of potash) and dilute sulphuric acid. Half the cyanogen passes over into the water of a cooled receiver as hydrocyanic acid, and part remains in combination with potassium and iron as a yellowish-white insoluble double salt (Everitt's salt). Some acid sulphate of potassium is also formed: thus—

$$2K_4FeCy_6 + 6H_2SO_4 = FeK_2FeCy_6 + 6KHSO_4 + 6HCy$$

CHARACTERS AND TESTS.—The pharmacopœial solution is a colourless volatile liquid of characteristic bitter-almond odour. Its taste has been variously described as "hot and bitter" (Taylor), or "cooling, afterwards irritating" (R. W. Smith); sp. gr. 0·997 (nearly that of pure water). If free from other acid it reddens litmus but transiently. It loses strength on exposure to air and light, but that which is prepared by the pharmacopœial process and kept in dark-coloured bottles may be retained for years without perceptible change. Stronger solutions alter more readily, and of the anhydrous acid (which has a sp. gr. of 0·697) a part evaporates on paper so quickly as to freeze the rest. Cyanides prevent fermentation, and are fatal to vegetable life (Dumas).

1. *The White or Silver Test.*—Nitrate of silver gives, with

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prussic acid solutions, a dense flocculent white precipitate of cyanide of silver, insoluble in cold, soluble in *boiling* nitric acid,—$HCy + AgNO_3 = AgCy + HNO_3$. This test may be conveniently applied to the detection of prussic acid vapour by means of two watch glasses, the lower one containing a little of the suspected solution, and the upper one, inverted over it, a few minims of nitrate solution (1 gr. to the oz.): the latter soon becomes opalescent, and when dry, leaves a white stain, showing under the microscope prisms or long plates interlaced. Cyanide of silver, like other insoluble cyanides, may be further tested by placing it in a narrow glass tube drawn out at one end and heating: cyanogen will escape and may be lighted at the pointed end; it burns with a rose-coloured flame, having a bluish halo.

2. *The Blue or Iron Test.*—This is applied by adding to the solution a little liquor potassæ and a few drops of a mixed solution of a proto- and per-salt of iron (protosulphate and perchloride are commonly used); a greenish-brown precipitate falls, which, on addition of a little dilute hydrochloric acid, becomes dark or Prussian blue in colour. The potassic cyanide, first formed, gives rise to ferro-cyanide and afterwards to ferric cyanide with the iron salts, thus:—

$$HCy + KHO = KCy + H_2O$$
$$2KCy + FeSO_4 = FeCy_2 + K_2SO_4$$
$$4KCy + FeCy_2 = K_4FeCy_6$$
$$3(K_4FeCy_6) + 2(Fe_2Cl_6) = 12(KCl) + Fe_4(FeCy_6)_3$$

The acid dissolves any excess of precipitated iron oxides that might obscure the colour.

3. *The Red or Sulphur Test.*—Add to the solution a few drops of ammonia and of yellow sulphide of ammonium; warm gently till colourless, and evaporate slowly; to the residue add a drop of acid solution of perchloride of iron; a blood-red colour (sulphocyanide of iron, Fe_26CyS) is developed; it is discharged by corrosive sublimate, and thus distinguished from meconic acid. In this test some free sulphur in the ammonium sulphide unites with the alkaline cyanide to form sulphocyanate of ammonia.

$$2AmCy + S_2 = 2AmCyS$$

The ammonia combines with excess of free sulphur, and forms,

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amongst other compounds, sulphydrate of ammonium, which should be removed by boiling and evaporation, and if this be not carried far enough, some of the latter compound remains and gives rise to black sulphide of iron instead of sulphocyanide on addition of the perchloride solution.

These two tests are also applicable to the vapour by means of watch glasses.

4. *The Copper Test.*—To the liquid, rendered slightly alkaline by liquor potassæ, add solution of sulphate of copper; a greenish-white precipitate falls, containing cyanate of potash and of copper with some blue oxide. When this is dissolved by a little hydrochloric acid, the precipitate becomes nearly white.

ABSORPTION AND ELIMINATION.—Hydrocyanic acid is absorbed to some extent, even through the unbroken skin, especially if a strong solution be applied with friction; from a wound, or from mucous membrane, it is, however, absorbed much more readily. When placed on the tongue or swallowed in the ordinary way, it passes sooner into the circulation than when injected into the stomach, rectum, or vagina (Coullon, Krimer). In less than thirty-six seconds after a little of the strong acid is placed on an animal's tongue it may be detected in the circulating blood (Krimer, Horn's Archiv, 1826): after intravenous injection, also, it quickly produces its effects, but most quickly after inhalation. Guinea-pigs made to inhale the anhydrous acid for one second, die within fifteen seconds, and strong rabbits exposed to the vapour for three seconds, are destroyed within thirty (Preyer, Die Blausäure, zw. Theil, 1870, s. 133). The weakly, the young, and the aged amongst warm-blooded animals are much more easily affected by the acid; whilst frogs, and all cold-blooded creatures, are much less sensitive to its action, and survive toxic doses for several hours. Horses are said to be insusceptible to quantities of one or two ounces (Amory, Boston Journal, 1866).

Although so rapidly poisonous to most animals as it is also to men, there is yet no difficulty in concluding that absorption must precede any general action, and Stillé has shown that if a tight ligature be placed round a limb exposed to the acid, constitutional effects do not occur, so long as the local is cut off

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from the general circulation (vol. ii., p. 222, 3rd ed.). Ordinary blood is not essential to its action, for the bloodless "salt frog" exhibits the same symptoms under prussic acid as the normal creature (Lewisson, Reichert's Archiv, 1870).

Elimination is rapid, and for ordinary medicinal doses is probably complete within an hour; even after a full or poisonous amount, if life can be prolonged for that time, recovery may be hoped for. The acid passes out partly by the saliva, to a slight extent by the kidneys, but mainly by the lungs, as evidenced by the characteristic odour of the breath.

PHYSIOLOGICAL ACTION.—*Internal.*—Digestive System.—Small medicinal doses—2 to 5 min. of the officinal acid—seldom exert more than a transient effect of sedative character on the gastric mucous membrane; 10 to 20 min. induce local irritation of the fauces and stomach, with increased flow of saliva, and nausea; breathing the vapour, or taking by the mouth 20 to 30 min. or more of the diluted acid, causes such symptoms in a marked degree, though not always immediately (Taylor).

Toxic Action.—If, with animals, such doses be used as allow time for a somewhat gradual poisoning, vertigo is noted as an early symptom, with loss of power over the muscles, so that the animal quickly falls; the breathing, at first perhaps hurried and panting, soon becomes slow and difficult, while the heart-beats are rapid and weak. Convulsions mark (according to Preyer) the *second* stage of cyanic poisoning; they may be tonic or clonic, and affect not only the limbs, but the respiratory muscles and the heart: livid features, protruding shining eyeballs, and congested veins evidence the obstructed circulation, and either death soon comes from asphyxia, or after a period of paralysis and torpor, recovery gradually ensues. Evacuations from the bladder and bowel commonly occur during the unconscious stage, and a peculiar shriek often, though not always, precedes death. *Post-mortem*, intense congestion of the larger venous trunks and the cerebral membranes is the most marked appearance.

In man, more than 60 min. of the dilute, or 1 gr. of the anhydrous acid, will be usually a fatal dose, though symptoms may not be developed for some minutes; after as much as ½ fl. oz., how-

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ever, they will come on in a few seconds, or even during the act of swallowing. Volition and power may be retained just long enough to walk a few paces, to arrange the bed-clothes, or to cork a phial; but suddenly the subject, if standing, will fall prostrate, often with a scream or in convulsions. Within two minutes he will be insensible, paralysed, with fixed and glistening eyes, dilated insensible pupils, cold clammy skin, and swollen cyanotic face: the jaw is set, saliva exudes from the mouth, and evacuations occur from the bladder and bowel: the breathing, at first perhaps hurried, soon becomes convulsive and gasping, with long pauses and prolonged expiration: the pulse, after a brief quickening, is soon imperceptible, and death occurs by asphyxia within three to five minutes from the fatal dose.[1]

Respiratory System.—In man, ordinary medicinal doses do not affect respiration, but 10 to 20 min. may render it irregular and laboured. Under small doses, the breathing-rate of animals either remains unaltered at first, or is markedly lowered; it is never increased. With larger doses and concentrated solutions, the course of poisoning is so rapid, that respirations can scarcely be counted; convulsive movements also interfere with observation, but we can say that in this stage the rate is lowered, and continues so. As the animal passes into a comatose condition, a slight rise may occur, which increases if recovery is proceeding, but which soon gives place to marked slowing and then complete cessation of breathing. The heart may continue to beat for some little time after this, and if so, even if in other respects the animal seems dead, *artificial respiration* will restore it to life.

The general character of the respiratory changes resembles (according to Preyer), not that occurring in apnœa, but that which occurs when the vagi are divided and the cut end of the central branch is stimulated, or irritated, by electricity. At the beginning of the poisoning the inspirations are deeper than normal, then follows a pause, and then short shallow expirations. In many instances during the convulsive stage there occurs on

[1] The glistening condition of the eye usually described, and the evacuation of the bladder and bowel, are not, I think, so constant as commonly supposed: in four cases within my experience, the former symptom was not present, and in only one did the evacuations occur.

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inspiration a tetanic spasm of the diaphragm, such as Traube found after direct vagus irritation.

Nervous System.—Doses which disturb the digestive and circulatory systems—10 to 20 min.—may cause not only giddiness, but also a sense of constriction and heaviness of the head, prominence of the eyes, some confusion of intellect, and muscular weakness. Upon which part of the nervous system the special effects of larger doses are exerted—whether upon the vagus, the nerve-centres, or the peripheral nerves—has been disputed.

Vagus Nerve.—Arguing from the conditions already described, and from the fact that poisoning by prussic acid is most rapid if the vapour be inhaled, Preyer concluded that its chief action was exerted on the vagus *terminals* in the lungs, stimulation, or rather irritation of them being propagated to the respiratory centre, and causing the phenomena of asphyxia. That the stimulation was not, in normal conditions, exerted directly on the respiratory *centre* he held to be evident from the fact, already noted, that section of the vagi—*i.e.*, interruption of communication between the ends and the centre—delayed the course of the poisoning and the time of death: the occasional occurrence of tetanic spasm of diaphragm he explained by a secondary transfer of irritation from the medulla to the *phrenic nerve*. In animals with divided vagi, the respiratory changes were somewhat different, and death in such cases was explained either by an action on the terminals of other (unknown) nerves of the lungs, or by direct action on the centre in the medulla, or when occurring under large doses, by direct paralysis of the heart.

Nerve-Centres.—On the other hand, Boehm and Knie, conclude that the main change is always exerted on the *central* nervous system—the medulla—the functions of which are for a brief period stimulated and then destroyed (Archiv f. Exper. Path. Klebs., Bd. ii., p. 137). In cats prepared for experiment according to their method, there occur under prussic acid at first two to four deep laboured inspirations, then quick and convulsive expiration, "resembling that caused by irritation of the superior laryngeal nerve" (Rosenthal); they observe no inspiratory cramp or tetanus, and no influence of the vagi, whether it be left entire or divided,

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upon the course of the poisoning, nor upon the heart (*v.* p. 268). (The practical result is that these observers attach no value to atropia as an antidote, though equally with Preyer they recognize the excellent results to be obtained by *artificial respiration.*)

I am not prepared to reconcile the differences between these and other observations, but in a more recent essay Preyer attributes the differences to *undue manipulation* of the animals, maintains his conclusions unaltered, and offers additional facts in support of some of them (Archiv f. Exper. Path. Klebs., April, 1875). We must add, however, that Lecorché and Meuriot, whilst agreeing with him that cyanic death is connected with intense excitation of the vagus nerve, and that section of the vagi delays it, yet attribute such excitation to a *central*, not peripheral, action of the poison. A striking experiment made by Prof. Jones bears in the same direction: having found, with alligators, that the internal giving of the poison did not easily or quickly take effect, he applied it *directly* to the medulla oblongata, and within sixty seconds there followed complete expiration of the air contained in the lungs, with collapse of those organs, and tetanic contraction of the respiratory muscles (New York Med. Record, vol. ii.).

The convulsions which often occur in cyanic poisoning are *cerebral* in origin, for they do not occur in parts situated below a transverse section of the spinal cord—*i.e.*, in parts with which cerebral communication has been interrupted (H. C. Wood). We may further conclude that they are connected with disturbed cerebral circulation, for they have been noticed to commence directly after cardiac arrest (Laschkewitsch, Coze).

Peripheral Nerves and Muscles.—We are unable to conclude positively with Preyer that the peripheral ends of the vagus receive the first and main influence of the poison, for the mere extent of absorbing surface and ready contact with blood in the lungs would go far to account for the greater rapidity of the effects of inhalation, and there is other evidence that the respiratory *centres* are affected. This question, however, apart, we may accept the careful observations of Kölliker, that peripheral sensory nerves are paralysed by *local contact* with sufficiently strong solutions, and the early disappearance of reflex function in cyanic poisoning is connected with such paralysis rather than

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with paralysis of the cord (Kiedrowski). Nerve-tissue placed in a solution of prussic acid loses its conducting power, and muscular tissue loses its irritability still more quickly, although the nerve-trunks are probably acted upon at the same time as the muscles after internal administration of the acid (Virchow's Archiv, Bd. x., p. 272). When the whole blood is rendered venous, as in later stages of poisoning, there is increased action of the contractile fibres of organic life (involuntary muscular tissue), and hence, often increased peristalsis of the intestine, contraction of the bladder, and evacuations from those viscera. The same result occurs sometimes in asphyxia from hanging, carbonic acid poisoning, etc., and is commonly attributed to the same cause (venosity of blood), though indeed it *may* result from *paralysis* of sphincters, as it does under chloroform, or during an epileptic attack.

Circulatory System.— Continued small doses—1 to 5 min.—given at moderate intervals of two to four hours, lessen the force and rapidity of the heart-action: 10 to 20 min. taken by the mouth, or inhaled, may cause giddiness and faintness, with slowing, or sometimes quickening, of the pulse, and suffusion of the face. With animals, full or large doses cause a sudden arrest in diastole; this continues for a variable time, and is followed by quickened action, and afterwards by diminution, and then by either gradual return to the normal number of beats, or total cessation according to the dose, and to the age, strength, etc., of the animals (Laschkewitsch, Preyer).

A point of much interest is the statement that *section of the vagi* in the neck prevents this primary diastolic arrest, and Preyer, who has studied the subject with the greatest care, and has made very numerous experiments, affirms that after such section, no slowing of the heart-action occurs under doses that would with uncut vagi stop the heart (Op. cit., erst. Theil, 1868, p. 35); also that death, under toxic doses, is much slower when these nerves are divided than when they are not. We know from Pflüger's researches that weak stimulation of the vagus causes slowing of the heart, and a very strong stimulus of it causes stoppage in diastole, and Preyer argues that the action of prussic acid on the heart is exerted through the *vagi* in accordance with these results, and the secondary and temporary quickening

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which occurs with certain doses is due to a secondary paralysis of the control-influence of the same nerves.

On the other hand, we have directly contradictory observations upon cats by Boehm and Knie, who found no primary diastolic arrest, and no influence exerted either way by section of the pneumogastrics; but their animals, though more accurately dosed, were in still less natural condition than those of Preyer, for they were chloralized, tracheotomized, and injected through an exposed jugular vein: we cannot think their observations conclusive (*v.* p. 265).

With very large toxic doses death is instantaneous, and the heart is arrested in diastole without any recurrence of ventricular contraction, though some movement of the auricles may be perceived on opening the chest (Lecorché and Meuriot, Archives Gén., t. xi., 6e série): with such doses the result is not influenced by section of the vagi, and death is presumed to follow direct cardiac paralysis (Preyer). Applied directly to the heart, the acid arrests its movement and destroys its muscular irritability.

Arterial pressure in the vessels is said to be increased under the action of prussic acid (Wahl), but according to Boehm and Knie, such increase is temporary only; the pressure soon falls below normal, and after large doses remains so for some time.

The startling rapidity of action of prussic acid suggests an immediate toxic effect on the *blood*, and there is indeed a remarkable colour-change induced, which has been thought to give a clue to the intimate working of the poison. Thus, if the jugular vein of a rabbit be exposed, and seen to contain dark blood, and a toxic dose of acid be then given by the mouth, so soon as convulsive movements indicate its taking effect, will the stream of venous blood take on a clear red colour, and the vessel greatly enlarge in size. If the blood be let flow from an incision, a similar change is observed, and if the right heart be examined *in situ*, the dark blood contained in it is equally seen to become red; it is so also in the nose and ears (Gaethgens, Med.-Chem. Untersuch., drit. Heft., Berlin, 1868, Hoppe-Seyler). This had been noticed, though with less detail, by earlier observers, by Vietz and others, by Claude Bernard (who got a similar result with carbonic oxide), and by Preyer, who found the same appearance caused not only by diluted sul-

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phuretted hydrogen, but also by the mere removal of any obstructions placed in the air-passages (Op. cit., p. 88). It is not therefore, due to a specific action of prussic acid, but is secondary to altered respiration, and although very interesting, has not the importance attached to it by Gaethgens. The apparently contradictory observations of Bischoff and others, to the effect that all the blood found in the body after cyanic poisoning is unusually dark and venous, are explained by a difference mainly in the *rapidity* of the poisonous action: if life be prolonged for a few minutes, the red colour is gradually replaced by dark, whilst if death be very sudden, red blood only is found in the heart—sometimes even on the following day (C. Bernard). In cold-blooded animals, the red colour persists much longer than in the warm-blooded (Preyer).

Theory of Action.—It is easier to ascertain, than it is at present to explain these facts. Hoppe-Seyler suggests that the red corpuscles lose for a time their power of giving up oxygen in the capillaries—that oxidation of tissue is suspended (Untersuch., 1866, erst. Heft, s. 140). Geinitz argued that a change in the *physical form* of the corpuscles would explain change of colour, and found that the acid mixed with blood *outside* the body caused various alterations of their form (Pflüger's Archiv, Bd. iii., 1870): but according to Preyer the blood of a poisoned animal taken from the vessels directly after death, and examined by the microscope, exhibits *no change* in the character of the corpuscles (Chemismus, Leipsic, 1840). He inquires whether the deepened breathing could for a time induce a hyper-oxygenated condition, as in animals dying from apnœa and found by Pflüger to have light-red blood (Archiv, i., p. 106), or whether the increased blood-pressure could drive the blood so quickly through the capillaries as to prevent its giving up oxygen as usual.

I cannot satisfy myself as to a clear explanation, but believe that during the first stage of cyanic poisoning oxidation is arrested, and that the venous condition of blood found in later stages of poisoning is connected with spasm of the pulmonary arterioles, and paralysis of the respiratory and cardiac muscles.

It would seem that no *permanent* toxic combination is found

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with the corpuscles; they are not at once fatally spoiled, nor is oxygen wholly driven out, but for the moment (and it may be finally) its interchange with tissues is prevented. The results of many careful spectroscopic examinations by Preyer and others, and of many laborious gas analyses by Gaethgens, confirm this view: the red blood shows still the absorption bands of oxyhæmoglobin, and the dark blood those of hæmoglobin, with little or no combined oxygen: outside the body, indeed, prussic acid destroys hæmoglobin (forming a new compound, cyanohæmoglobin, which is destitute of ozonizing power), but apparently does not do so during life. Laschkewitsch could not detect such compound, but on the contrary found oxyhæmoglobin (Reichert's Archiv, 1868), and more recently, Hiller and Wagner, examining blood whilst still within the mesenteric vessels, obtained characteristic though feeble lines of oxyhæmoglobin (Lancet, ii., 1877). If withdrawn from the body, the dark blood, shaken up with oxygen, resumes its normal red tint, and—a most important practical point—the condition just described may be remedied during life by securing access of additional oxygen by *artificial respiration*.

Gaethgens proved (1) that the property of de-oxygenated blood to abstract oxygen from surrounding media is not destroyed by prussic acid; (2) that blood saturated with oxygen exposed to the action of prussic acid gives off no oxygen, and that substances which would usually withdraw oxygen from fresh blood do so with much difficulty under the influence of the acid. Both oxygen and carbonic acid are excreted in less than normal *total* quantity during the poisoning (on account of the slow rate of the breathing), but not only is the actual percentage of carbonic acid in the expired air less than normal, but the *percentage* of oxygen in the same expired air is greater than normal—*i.e.*, it has not been used up in the system.

SYNERGISTS.—Cyanides owe their activity to prussic acid, and exert a similar action. Cherry-laurel water, and essence of bitter almonds, owe their chief properties to the same acid. All substances which hinder hæmatosis, or the union of oxygen with the blood-corpuscles—such as arsenic, antimony, and most sedatives—favour the action of hydrocyanic acid.

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ANTAGONISTS—INCOMPATIBLES.—The effect of medicinal doses is lessened by diffusible stimulants, by strong acids or alkalies, and by opium (Gubler). Warmth quickly volatilizes the acid, otherwise it favours its action. The most dependable antidote to poisonous doses is *oxygen*, which is best introduced into the system by *artificial respiration*.

Preyer strongly recommends atropia as a "dynamic antidote," since it acts upon the vagus nerve in a manner contrary to that of hydrocyanic acid (*v.* Vegetable Kingdom). I must agree with Boehm and others that his observations are somewhat wanting in scientific accuracy, as when he speaks of injecting "a little atropia," or says simply, "Injected sulphate of atropia, and afterwards a rather large dose of prussic acid, which would assuredly have caused death" (Versuche, p. 74, 36-37), and although Bartholow, Lecorché, and others have failed to obtain confirmative evidence, still they hold true to a certain extent. A practical difficulty in their useful application must always be the extremely rapid course of cyanic poisoning, and the (comparatively) slow diffusion of atropia; to be of any service, the alkaloid would have to be used almost on the instant of poisoning.

Sal-ammoniac was strongly recommended by J. Murray (Edin. Phil. Journ., 1822), and although Orfila and Elwert showed that it could not be depended upon as an antidote, I think this and other compounds of ammonia well deserve further trial. Modern observation credits the drug with a power of directly stimulating the respiratory centres (*v.* p. 329), and this, in addition to its general stimulating power, seems specially to indicate its use in cyanic poisoning.

Chlorine and chlorine water have been used with advantage by A. Chevallier and Orfila, but they are not manageable. Turpentine, though recommended as a specific antidote, has only value as a stimulant. I cannot see that phosphorus offers a resource of value, nor can much be expected from coffee.

Some indefinite evidence exists as to an antidotal power possessed by strychnia. Thus, a puppy that had taken $\frac{1}{2}$ gr. of prussic acid quickly recovered after swallowing a dose of the alkaloid (Med. Times, ii., 1859), and some other instances are reported (Lancet, i., 1868). Stannius also found that strychnia-

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convulsions were modified by the acid, but Dr. Lauder Brunton concluded "that although the acid may somewhat lessen the convulsion, it cannot be employed as an antidote to strychnia with any hope of success," and G. Harley thought "that it rather hastened death from strychnia" (Med. Times, ii., 1861).

Silver and metallic oxides generally, form insoluble compounds with prussic acid, and fresh proto-carbonate of iron has been recommended as antidotal by Messrs. Smith (Med.-Chir. Trans., ii., 1865); practically, however, their influence can scarcely be exerted quickly enough.

It remains that *artificial respiration* is the main resource in all forms and stages of cyanic poisoning—it may be carried out in the ordinary methods, or excited by the sudden affusion of water, first cold and then hot, thrown over head and chest. This does not exclude the use of an emetic, the application of ammonia to the nostrils, or even its injection into the veins, whilst stimulating frictions and warmth should be applied to the limbs; by the steady use of these means, patients have revived from apparently hopeless insensibility, and if life can be prolonged for an hour, the chances of recovery become greatly increased.

THERAPEUTICAL ACTION. — *External.* — **Urticaria—Prurigo.**—I have seen great relief given, even in obstinate forms of these maladies, by lotions containing hydrocyanic acid in sufficient strength. Pereira states that he did not observe relief in such cases, but he seems to have used only 2 dr. of acid in ½ pint of water. I have recommended ½ oz. or more in 10 oz. of liquid (rose water), and have never seen ill effects, but such a remedy should not be placed in careless hands, nor ordered if the skin be excoriated; *sometimes* a much smaller proportion will answer well, and especially when mixed with lead or soda lotion. The cyanide of potassium has also been used for lotion and ointment in the strength of ½ dr. to 8 oz. of liquid, or 1 oz. of cerate; a greater strength has caused severe irritation.

Headache—Neuralgia.—Trousseau used a lotion of cyanide locally in cases of sick headache, and Fuller recommended the painting of neuralgic parts with a strong preparation of the

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acid (½ oz. with 2 dr. each of glycerine and water), but such applications have rightly fallen into disuse.

Eye-Diseases.—The same may be said of cyanic lotions and vapours in the treatment of eye-disease, for which at one time they were in vogue. J. V. Solomon recorded numerous cases of conjunctivitis (sub-acute), ophthalmia, iritis, photophobia, etc., which were relieved by applications of dilute Scheele's acid, 1 part in 3 (Med. Times, i., 1852). Turnbull invented an instrument for applying the strong vapour to the eye, but this sometimes produced serious symptoms; in one case of its use, Sir W. Wilde describes faintness, giddiness, and unconsciousness (Med. Times, i., 1861). Nunnely records that he found strong applications to the conjunctiva poison as quickly as by the stomach (Trans. Prov. Med. Surg. Assoc., N. S., iii., p. 58).

Ringworm.—Dr. Gee has found advantage from a lotion containing ½ oz. of sulphocyanide of potassium in 7 oz. of water with 1 oz. of glycerine, kept applied to the scalp. The effect must be watched, and a daily washing with soap and water practised.

THERAPEUTICAL ACTION.—*Internal.*—Hydrocyanic acid has a certain value in relieving spasmodic pain and irritation, but its use is limited by the extreme care required in dosage, and the risk of causing unpleasant symptoms; yet to say with Trousseau that "it is often dangerous, almost always useless, and very rarely curative," greatly overstates the facts.

Gastrodynia.—Enterodynia.—Cases described under these names, and which seem to be frequently of neuralgic type, are often quickly relieved by suitable doses of prussic acid. Pereira gives instances of very severe spasmodic pain, where there was no complaint of pyrexia, of faintness, nor of any ordinary symptoms of dyspepsia; the pain was such as to lead to suspicion of organic disease, but it disappeared under the use of the acid. In one case it was seated in the intestine, came on about two p.m., and lasted until night, unrelieved by many remedies until this one was used, and Pereira made the further observation that its action is exerted quickly, and either produces complete relief or none at all. Sir T. Watson

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"has seen more rapid and decided relief from it in gastrodynia than from anything else."

Dyspepsia.—Dr. Elliotson, in a special treatise on the subject, makes several groups of cases in which he found prussic acid extremely useful; some were marked by pain and tenderness only, others by flatulence, nausea, anorexia, liver-troubles, and vertigo, others again by pyrosis, heartburn, and palpitation (Med.-Chir. Rev., i., 1821). A. T. Thompson made somewhat similar observations, especially noting benefit when the tongue was hot, red, and sore (Dispensatory). Bailey also published illustrative cases (London Med. Repos., 1828), and alluded to its value when there was sympathetic heart-disturbance, palpitation, etc. In such cases, it is still in frequent use, although other remedies may be required if there be marked symptoms of unhealthy secretion. Disappointment as to its effects may be sometimes traced to the inertness from age of the preparation, or to admixture with other drugs.

Vomiting.—The acid is useful in the vomiting of fever, and in sympathetic vomiting, and is sometimes indicated in that of ordinary gastric derangement: it may be added to effervescent mixtures, or to bismuth, but as a rule is better given alone in distilled water. In some patients, or in some conditions, and more especially when the dose is too large, nausea and vomiting seem to be increased or caused by the drug, and then it is better omitted: on the other hand, I have seen severe cases recover with 6 to 8-min. doses, when smaller doses and all ordinary means had failed. In simple intestinal obstruction, even when fæcal vomiting had occurred, I have used 10-min. doses with the effect of staying the vomiting, but care is necessary in watching the results. Dr. Brinton found the acid useful in the vomiting of gastric ulcer; Dr. Harley combined it with bismuth, opium, etc., in that of enteric fever; Pereira recommended it in the vomiting and purging of phthisis, and even of cholera, and it may well be tried in the "nervous" form of vomiting, that connected with pregnancy, or with cerebral concussion or disorder.

Phthisis.—In the early part of this century Dr. Granville published a small treatise "to establish the claims of a new and powerful remedy," and in his second edition (1820) congratulates

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himself on the conclusive and numerous facts which have proved he was "not indulging in the chimeras of a revery" when he recommended the prussic acid for treating, if not curing, consumption. Being before the days of physical diagnosis, his cases scarcely bear examination, and his peculiar egotistic style jars upon the professional reader; but he may be credited with pointing out the relief often given to the general nervous irritability, the dyspepsia and harassing cough of phthisical subjects. The exaggerated views entertained both by the eminent Majendie and by Granville as to its powers of checking the disorder and curing asthma, chronic cough, etc., have not been verified by later experience. We can only say that it is a useful palliative for the irritative dry cough, especially in cases when morphia is not suitable, and that with alkalies and calumba it is often serviceable in phthisical dyspepsia.

Whooping-Cough—"Nervous Cough."—Dr. Granville states, "without presumption," that in almost every case of whooping-cough this medicine, given early, removes the disease (p. 64), and Dr. Hamilton Roe, in a special treatise (1838), records equally excellent results. He was rather in advance of his time in concluding pertussis to be not always inflammatory, but "a nervous affection, having its seat in the mucous membrane of the bronchi and the pneumogastric nerve," and for the "nervous element," *i.e.*, the peculiar whooping or spasmodic cough, he valued prussic acid more than opium, belladonna, or any other remedies then in use: he gave very full doses, such as ¾ min. of Scheele's acid to infants, and 1½ drops every quarter-hour for twelve hours to a child of ten years. I think this another illustration of the benefit to be obtained from the medicine when it may be justifiably and yet cautiously pressed, but for average practice it would be dangerous, and I agree with Sir T. Watson, who thinks the remedy in such doses "too gigantic for such young subjects;" also with Dr. C. West, who finds it "sometimes magical" for diminishing the frequency and severity of the paroxysm, but sometimes inert, sometimes poisonous. Dr. Atlee, judging from 200 cases, gives a most favourable report of it (Amer. Journ., vol. x.); and my own experience is decidedly in the same direction—the more purely nervous the paroxysms, the better will the remedy act, though some diffi-

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culty in graduating its dose will always remain: also, as is well known, the results obtained from remedies unaccountably vary in different epidemics and different individuals. In other forms of irritative cough, connected with spinal or vagus irritation, I have seen more benefit from this acid than from any ordinary sedatives; and the long-recognized clinical value of the drug in such conditions is of marked interest taken in connection with the special effect on the medulla and vagus, mentioned under physiological action.

Asthma.—Much relief may be given to patients suffering from simple spasmodic asthma, by small and repeated doses of prussic acid.

Palpitation.—Whether palpitation arises from cardiac hypertrophy or from ordinary functional derangement of the heart dependent upon nervous exhaustion or dyspepsia, hydrocyanic acid will often prove useful.

Vertigo—Cerebral Irritation—Mania.—The acid certainly exerts some control over exalted cerebral function, whether by acting through the circulation or otherwise. Vertigo, especially, if dependent on gastric derangement, may be relieved by it. Dr. McLeod has furnished evidence of its calmative power in acute mania and acute melancholia, recording forty cases, in most of which the relief given to violent excitement was marked and rapid; about 5 min. of Scheele's acid was the usual dose, or 3 min. injected under the skin (Med. Times, i., 1862).

In **Delirium Tremens**, Dr. Dow has seen it serviceable (B. M. J., i., 1873), and Dr. Maudsley recommends its combination with digitalis (Practitioner, Jan., 1869, vol. ix).

PREPARATIONS AND DOSE. — *Acidum hydrocyanicum dilutum* (contains 2 per cent. of anhydrous acid): dose, 2 to 8 min. *Vapor acidi hydrocyanici* (inhalation) is prepared with 10 to 15 min. in 1 fl. dr. of cold water. "Mix in a suitable apparatus, and let the vapour that arises be inhaled." *Lotio:* 2 dr. to ½ oz. in ½ pint of rose water; it should not be applied to an abraded skin. Anhydrous prussic acid being one of the most active and rapid poisons known, should never be prescribed; neither should Scheele's prussic acid, which contains 4 per cent. of anhydrous acid.

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ACIDUM NITRICUM—NITRIC ACID—AQUA FORTIS, HNO_3, = 63.

Nitric acid, the highest known oxide of nitrogen, may be detected in the atmosphere after thunder-storms, for electricity determines the necessary combination of the gases. United with potash, soda, lime, or ammonia, it forms a nitrate which is found native in efflorescence on the soil of some countries; it occurs, also, in some minerals and in certain plants, *e.g.*, as potash nitrate in pareira root.

PREPARATION.—Being a volatile acid, it may be prepared from any nitrate (usually a nitrate of potash or soda), by distilling it with the more stable sulphuric acid, when sulphate of potash is formed, and nitric acid being set free, rises with the vapour of water and condenses in the receiver.

$$KNO_3 + H_2SO_4 = HNO_3 + KHSO_4.$$

Of anhydrous acid, it contains 60 per cent.

The dilute nitric acid contains 6 oz. of the strong acid in 31 oz. of distilled water, or about 1 min. in every 5 min. Heat is developed during its preparation, and condensation of volume occurs.

CHARACTERS AND TESTS.—The pure acid, protected from light, remains colourless, but if exposed becomes yellowish in colour, from development of orange-coloured oxides, mainly N_2O_4 (nitric peroxide); at a sp. gr. of 1·42 it is a stable compound, boils at 250°, and distils over unchanged; it has a very sour, corrosive taste, and an acrid, suffocating odour; its affinity for water is great, and the white fumes which it emits on exposure are caused by the combination of its invisible vapour with atmospheric moisture forming a cloud of minute drops.

A good test for nitric acid is its action on metallic copper or iron; when *undiluted* and poured on them, it gives dense red vapours of peroxide of nitrogen and other oxides, but if first *diluted*, a colourless gas, nitric oxide, NO, is given off, which changes into peroxide, N_2O_4, and becomes orange-red in colour on contact with the air. If the colourless gas, NO, be passed into a solution of protosulphate of iron, it will combine with a

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portion of it, causing a dark brown colour. Morphia and brucia are coloured bright red by the acid.

There is no precipitation test for nitric acid, because all neutral nitrates are soluble, but its adulteration with sulphuric or hydrochloric acid is detected by chloride of barium and nitrate of silver respectively.

Nitric acid is a powerful oxidizing agent, and is used in pharmacy to prepare the nitrates of different metals; also for the making of certain organic compounds, as gun-cotton, nitrite of amyl, etc.

ABSORPTION AND ELIMINATION.—Dilute nitric acid in medicinal doses is diffusible and readily absorbed. In the blood it either combines with alkaline bases forming nitrates, or it circulates in a free state, or loosely joined (*invisqué*) with albumen (Gubler): it cannot be detected *free* in the blood by analysis. It is eliminated mainly by the urine as nitrate of potash or soda, not as free acid; yet it highly increases the acidity of the secretion by liberating acids weaker than itself (such as uric and lactic acids) from their combinations. From its effects upon the intestinal glandular structure, and from the comparatively small amount passed in the urine, it is probable that some is excreted by the lower bowel.

PHYSIOLOGICAL ACTION.—*External.*—Strong nitric acid applied but for a moment, stains organic tissue yellow, and leads to desquamation of the epidermis; if applied firmly and for longer time, it exerts a potent caustic effect, due to abstraction of the water from the tissues and combination of the acid with alkaline bases; xantho-proteic or -picric acid is also formed, and the part becomes yellow.

Dilute solutions exert a stimulant, moderately astringent effect; by continued contact they change most animal and vegetable substances into oxalic, malic, or carbonic acids (H. C. Wood, Elements, 2nd ed., p. 96). Nitric peroxide is an efficient but irritating disinfectant.

PHYSIOLOGICAL ACTION. — *Internal.* — For a general statement as to the action of acids on the organism, reference may be made to hydrochloric acid.

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Digestive System.—Given internally, in medicinal doses, dilute nitric acid exerts a stimulant effect on the glandular system of the alimentary canal, and some tonic bracing effect on the mucous membrane, so that appetite is improved by it, and undue secretion lessened; this is probably owing to a direct local action. Salivation sometimes occurs under the use of nitric acid, either in consequence of the gastric irritation, or of direct stimulation of the salivary glands by the medicine. It is commonly credited with some power of stimulating the secretion and excretion of bile.

Large doses act like other violently corrosive irritant poisons. In a case that proved fatal on the eighth day after swallowing 1 dr. of the strong acid, the œsophagus and stomach were found inflamed and ulcerated, the colon was in the same state, but the small intestine was sound; suppression of urine had occurred.

SYNERGISTS—ANTAGONISTS.—The same as those of sulphuric acid.

THERAPEUTICAL ACTION.—*External.*—**Disinfectant.**—Nitrous fumes may be generated by the action of sulphuric acid on nitrate of potash. They efficiently disinfect unhealthy wards, prisons, etc., but the use of less irritating substances has practically replaced this method.

Phagedænic Ulceration.—In cases of sloughing chancre, of phagedæna, of hospital gangrene, etc., when it is necessary to destroy portions of diseased tissue, and to stimulate to healthy action, strong nitric acid is one of the best caustics in use. The affected part should be cleansed and dried, so that the acid be not too diluted by secretion, the neighbouring parts should be protected by oil or ointment, and the caustic then thoroughly applied with a glass brush, splinter of wood, or pledget of lint, until a firm dry yellowish mass is formed; the pain is at first severe, but soon subsides under cold water dressings, the eschar formed is not very deep, and usually separates in one or two days; the application may sometimes require to be repeated.

Bubo.—The strong acid may, with advantage, be lightly pencilled over torpid suppurating buboes, to destroy the integument and stimulate to healthy discharge; should a sinus be

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formed, the upper wall should be touched in the same manner. (Lancet, ii., 1867, p. 796).

Lupus.—The same application is indicated for the indolent edges of an ulcerating lupus, though acid nitrate of mercury is perhaps better.

Uterine Disease.—Dr. Lombe Atthill has had the best results from applications of strong nitric acid to the interior of the uterus, in cases of fungoid granulation and excessive hæmorrhage: lint bound on a uterine probe conveys the caustic through a small speculum placed in the cervix (Obstet. Journ., June, 1873, and Treatise). It is a good application also in chronic inflammatory disease of the same part and in granular erosion of cervix if there be not excessive tenderness (B. M. J., i., 1876). H. Lee has found the acid good in uterine disease, if the mucous membrane be not too much thickened; it is important that it be not diluted by secretion, and that an alkaline injection be used after it (Lancet, i., 1874). As injurious effects have sometimes followed the use of nitrate of mercury and of strong iron solutions, I myself prefer the nitric acid for vaginal and uterine disease of the kinds named, but in cases of hæmorrhage from the vagina or uterine neck, connected, *e.g.*, with carcinoma, I think the perchloride or persulphate of iron mixed with glycerine, are better hæmostatics.

Internal Hæmorrhoids.—It has been thought that strong nitric acid would supersede all operative interference in this disorder, but its curative power is really somewhat limited.

Its local application is only useful in small granular piles, and in "velvety" conditions of the mucous membrane; it checks the bleeding, but severe hæmorrhage may occur when the slough separates. One or two applications ought to suffice for the cure of such a condition, but for large masses, or for hæmorrhoids with narrow vascular attachments, other treatment is better. Billroth, however, reports much success with nitric acid in most forms of internal hæmorrhoids, but especially in the flat form: after protrusion, he applies the remedy till the part is "stiff and yellowish-grey in colour," and then oils it well—he notes the importance of not touching sound parts with the acid, for it causes great pain (Ranking, i., 1872.) Dr. Houston first proposed this treatment (Dub. Med. Journ.,

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vols. xxiii.—xxvi.), and Mr. Henry Smith has used it extensively, and written in its favour.

In less severe cases where the parts bleed and are somewhat swollen, Dr. Ringer recommends a lotion containing 1 to 1½ dr. dilute acid to ½ pint water.

Prolapsus Recti.—If the strong acid be applied in one or two horizontal bands to the prolapsed mucous membrane of the rectum, in such a degree as to cause moderate but not too deep sloughing, these bands, on healing, will leave cicatrices which by their contraction are often sufficient to cure the complaint. In children, in whom prolapsus ani is rather common, benefit is often obtained from bathing the part with a weak nitric acid lotion, and giving the same acid internally.

Condylomata on the limbs or genitals, especially when of a syphilitic origin, disappear under the external use of nitric acid.

Warts and Corns.—Erasmus Wilson recommends nitric acid for the treatment of callosities, the cauterized portion being removed occasionally by the knife. I have used nitric acid extensively for the removal of moles on the face; the cicatrices are hardly visible.

Nævi.—Superficial nævi may be safely destroyed by painting with strong nitric acid; Mr. T. Holmes speaks highly of this method. Due precaution should be taken to protect the sound skin, and an alkaline lotion should be used afterwards. If the affected part be extensive, a portion only should be treated at one time, the caustic being applied about every second day, until its full effect be produced (Lancet, ii., 1866, and 1867). For small nævi on the face, I can recommend puncture with a needle dipped in the acid: it is safe, effective, and leaves comparatively little scar.

Indolent Ulcers.—For ordinary indolent or moderately sloughing ulceration, a lotion containing nitric acid diluted, about 1 dr. in ½ pint of water, is a good dressing.

Pruritus.—A similar lotion will often relieve itching in papular and neurotic diseases, such as lichen and prurigo; it may be conjoined with prussic acid, or with the liquor carbonis detergens.

Alopecia.—The acid, diluted with so much olive oil as will prevent the caustic though not the stimulant effects, makes a good liniment in some cases of falling off of the hair from debility.

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THERAPEUTICAL ACTION. — *Internal.* — Dyspepsia — Debility.—Dilute nitric acid is a serviceable tonic in cases of nerve-debility and of convalescence from acute disease, when appetite and digestive power are impaired. It acts well in combination with a few minims of tincture of nux vomica, stimulating the gastric glands and the biliary secretions, and may be given between meals, or shortly before or after, according to the conditions already mentioned under hydrochloric acid (*v.* p. 253).

Hepatic Disorder.—Nitric acid has long been held in repute for the treatment of chronic hepatic congestion, or chronic hepatitis, especially when occurring in Anglo-Indians, and after mercurials have been used. Dr. Murchison met with marked improvement, even in cases of *waxy liver*, from the continued use of nitric acid with vegetable bitters (Diseases of Liver, 1868, p. 33), but in later writings he remarks that there is no evidence of its assisting bile-flow, and that its action is less direct than that of alkalies; that in congestion (of acute character), or when lithiasis is present, it either does no good, or aggravates the malady, though it may relieve the dyspepsia of debility: he sometimes gives alkalies before a meal, and acid after (B. M. J., i., 1874). R. Martin, Thudichum, and indeed the majority of writers twenty years ago, allowed to nitric acid a larger sphere of usefulness in hepatic disorder, jaundice, etc.; it was presumed to "lixiviate biliary deposits, tone digestion, and act antiseptically" (B. M. J., ii., 1860). Annesley noted that it acted better, the more freely it was diluted—he used it in chronic splenic disorder. I have found nitric acid useful in chronic hepatitis, when watery diarrhœa and constipation occur alternately.

Phosphatic Urine—Chronic Cystitis.—Sir B. Brodie constantly employed strong nitric acid, in full doses—30 min. or more—largely diluted, and given in divided doses during the day, for phosphatic and alkaline urine. In cases of chronic cystitis, and even of phosphatic calculus, he also employed local injections containing 1 to 2 min. of the strong acid in the ounce of warm water. The best mode of administering nitric acid under these conditions is to give 5 to 10 min. of the dilute acid in 1 or 2 oz. of decoction of pareira brava every three or four hours.

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Diarrhœa.—When the dejections are frequent, serous or "watery" in character, especially if markedly alkaline, and if there be no evidence of acute inflammation and not much pain, then nitric acid acts well, and in cases of profuse purging from summer heat, and in the diarrhœa of phthisis, it has a deserved repute: if necessary, it may be combined with a small quantity of opium. In dysenteric diarrhœa with tenesmus, blood, and profuse discharge of mucus, nitric acid acts well. Dr. Hope had reason to prefer the dilute *nitrous* to the nitric acid; he gave 15-min. doses, with laudanum and camphor water, in most forms of diarrhœa and chronic dysentery, with much success. Dr. H. C. Wood found it succeed in some cases where nitric acid had failed: it is, however, unstable, and requires to be recently prepared.

Constipation.—Dr. Graves says, "In constipated habits I have occasionally derived very remarkable benefit from the use of nitric acid given in sufficient doses. It seems, like the carbonate of iron, to possess the advantage of combining tonic with aperient qualities" (Clin. Medicine, ii., p. 215). I think that this different action of the medicine depends upon dose, and perhaps combination, and is not contradictory to that mentioned in the last section. Nitric acid in *small* or moderate doses is astringent, especially if prescribed with opium; but nitric acid in *full* doses has an aperient effect, especially in combination with bitter infusion, such as gentian; this may be traced either to direct intestinal irritation or to hepatic stimulation.

Otorrhœa occurring in scrofulous children or in syphilitic patients, is often quickly controlled by a course of this acid.

Purulent Ophthalmia, with extensive ulceration of the cornea, whether of a gonorrhœal or scrofulous form, is much benefited by a course of 5 to 10 min. of the dilute acid three or four times a day, together with local treatment.

Fevers.—Dr. Osborne has recorded a good experience of nitric acid in typhoid fever (Lancet, ii., 1862), and Dr. Bailey (U.S.) in intermittents—he prescribed it to relieve profuse sweating, and unexpectedly found a curative effect on the ague: of ninety cases, eighty made a rapid recovery. Dr. Hammond has corroborated his results (Ranking, 1862).

Secondary Syphilis.—A course of dilute nitric acid will

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often be of service in later syphilitic cachexia, especially after mercurials have been used, and in debilitated subjects. It benefits ulcerations of the mouth, throat, and nose, and also periosteal swellings, and may be applied at the same time in the form of bath—1 to 2 oz. for each bath. Mercurial salivation is relieved by the acid.

Skin-Diseases.—In chronic syphilitic cutaneous eruption, such as rupia or psoriasis, this acid has been rightly commended. In ordinary, non-specific disorder, it is indicated whenever general debility is a marked symptom, and especially when nerve-power is impaired. Dr. Tilbury Fox frequently gave it, in conjunction with a bitter tonic, for psoriasis in weakly subjects.

Chronic Laryngeal Congestion.—In this malady, when brought on by excessive vocal exertion, as in singers and readers, 5 to 6-min. doses of dilute nitric acid in sugared water have been found very useful, bracing up the relaxed membrane and throat follicles, and relieving hoarseness; also in chronic laryngitis dependent upon a syphilitic taint, it is of much use.

Chronic Bronchitis.—I agree with some good observations made by Dr. Glover, drawing attention to the benefit obtained sometimes from nitric acid in cases of chronic catarrh and bronchitis when secretion is fairly free, when nerve-exhaustion is a prominent symptom, and when ammonia and expectorants fail to relieve (Lancet, i., 1865); this fact deserves more attention than it has yet received. Dr. Glover combines nitrous ether with the acid, and sometimes tinct. camph. co. is also indicated, the precipitated camphor, etc., being readily suspended in cetraria or mucilage.

Pertussis.—Nitric acid has been found by some observers valuable in relieving the spasmodic recurrent attacks of cough, and lessening profuse expectoration; and it may certainly be credited with tonic bracing action on the faucial and laryngeal membranes. Arnoldi, who introduced this mode of treatment, ordered as much acid as would render a tumblerful of sugared water "like lemon juice," to be taken every three or four hours. Dr. Gibb, who reported the best results, gave as much as 10 min. to infants, and 40 min. to children of ten years; and some other practitioners have used this medicine with success,

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as Ussher (Med. Times, i., 1862) and Berry—in an epidemic at Lancaster—who found it effective, safe, and cheap (Med. Times, i., 1873). I have been reluctant to press it for fear of injuring teeth, and when I have used it as freely as could be borne, I have not seen definite benefit.

PREPARATIONS AND DOSE.—*Acidum nitricum*—*Aqua fortis:* dose, 1 to 3 min. freely diluted. *Acidum nitricum dilutum:* dose, 10 to 30 min. freely diluted.

ADULTERATIONS. — Chiefly sulphuric and hydrochloric acids.

ACIDUM PHOSPHORICUM DILUTUM—DILUTE PHOSPHORIC ACID, H_3PO_4, = 98.

This acid is rather widely diffused, being found free or combined with alkaline and earthy bases in soils, and in many vegetables and fruits, such as wheat, potatoes, rice, lemons, etc., also in fish, and in the bones, nerves, and flesh of animals, and according to Marcet, more in the lungs than in other parts; also in the urine and other secretions.

PREPARATION.—The officinal (tribasic) acid is prepared by distilling phosphorus with dilute nitric acid by the aid of gentle heat; some of the latter acid passes over in vapour, and therefore the distillate is returned to the retort occasionally in order to prevent loss: it is finally concentrated to a syrupy consistence (heat being used to get rid of nitrous fumes), and the resulting strong phosphoric acid is diluted with water to a sp. gr. of 1·08, which represents about 14 per cent. of acid.

CHARACTERS AND TESTS. — Tribasic or orthophosphorous acid is a colourless, inodorous liquid, of acid, not unpleasant taste, and even when concentrated, not corrosive, nor coagulating albumen. It gives with ammonio-nitrate of silver, a canary-yellow precipitate of phosphate.

There are two other forms of phosphoric acid, not officinal, but

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of much interest to the chemist. If heat be applied to the common acid it loses water, and its first anhydride (pyrophosphoric or bibasic acid, $H_4P_2O_7$) is produced: by a higher heat, more water is driven off, and its second anhydride, glacial or metaphosphoric or monobasic acid, HPO_3, is formed. This is in the American Pharmacopœia, and is a colourless, ice-like, deliquescent solid: it is the only form which coagulates albumen.

All soluble phosphates give a white crystalline precipitate with sulphate of magnesia, after the addition of sal-ammoniac and liquor ammoniæ (ammonio-magnesian phosphate, or "triple phosphate"—$MgNH_4PO_4$).

ABSORPTION AND ELIMINATION.—Phosphoric acid is readily absorbed by the stomach. Ordinary doses combine with alkalies—potash or soda salts—probably displacing them from combination with weaker acids, lactic or carbonic, and forming phosphates; after larger or poisonous doses, Hoffmann states that he has found it free in the blood or loosely combined with albumen (Journ. de Chem., June, 1868).

As phosphate it is mainly eliminated in the urine, and Böcker found the excretion of potash phosphate especially increased under its use: some acid may possibly be eliminated in a free state.

PHYSIOLOGICAL ACTION.—The action of phosphoric acid bears a general resemblance to that of sulphuric acid, but in medicinal doses it is less liable to irritate the stomach or interfere with digestion, and it exerts a more stimulating effect on the general system: it has a more pleasant taste than the other inorganic acids. The pharmacopœial solution does not coagulate albuminous tissues, and like oxalic and tartaric acid only coagulates egg-albumen after addition of chloride of sodium or other neutral salt.

Circulatory System.—The effect of moderate doses of phosphoric acid is stimulant, but of large doses, especially when injected into the blood-current, depressant. Two cub. centim. of a 4 per cent. solution given to a frog, increased the pulse-frequency, and the direct application of acid to the frog's heart at first strengthened though it afterwards weakened the contractions;

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after death, the heart-muscle was non-excitable (Munk and Leyden). In warm-blooded animals, after the subcutaneous injection of about 8 grammes, slowness, weakness, and irregularity of heart-beat occurred, with retarded respiration, lowered temperature, prostration, and death (Meyer).

After injections of phosphoric acid into the jugular vein, the blood-pressure and the pulse-frequency are lowered, although after small quantities they quickly rise again. Pavy found that he could inject 8 or 10 dr. of the pharmacopœial solution into the jugular of a dog without causing death, and if, in any animal, the maximum amount compatible with life was injected, the urine and the arterial blood became highly charged with sugar (Guy's Hospital Reports, vol. vii., 1861). We may connect this result with the fact that phosphoric acid acts even more powerfully than hydrochloric in diminishing the alkalinity of blood (Walter), whilst, on the other hand, injections of soda prevent the production of artificial diabetes; but the full bearing of such facts is not yet known. Injections of acid into the carotid caused primary slowing of pulse with secondary quickening before death, strong inspiratory cramp, convulsions and coma (quoted by Husemann). After death from excessive quantities, ecchymoses were almost always found in the lungs, and the blood was altered, being dark but fluid, and not easily coagulable, sometimes gelatinous. The effect on the blood is not always the same: thus, Pavy in one experiment found the "large venous trunks in the liver plugged with coagulated blood" after an injection of 30 dr. of acid into the duodenum; and Gubler says, "introduced into the veins of animals, phosphoric acid coagulates the blood and causes death in a few minutes:" this depends on the dose and concentration. Neumann states that the corpuscles are not destroyed by the acid, but may be much altered in form and vital properties.

The action upon man is of more practical interest, but very few investigations have been made with phosphoric acid. Bobrick records a rise of the pulse from 70 to 90 beats per minute, but in the course of an hour it fell to 66; this was after a dose of ½ oz. A rigor also occurred, the cause of which is not easy to trace, but it was followed by a pleasant sensation of warmth.

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Dr. J. B. Andrews (N. Y.) administered doses of from 1 to 3 dr., and investigated the effect by means of sphygmograms taken at intervals of from fifteen minutes to one hour. He says, "Within the first interval there is an increase in the force of the pulsations, though there is little change in the number during the whole time of experimentation. The increase is most marked after the lapse of from one to two hours, and it is not till after several hours that the pulse returns to its normal condition. The first experiment I made upon myself, beginning with 20 drops, and continuing the use of the remedy in increased doses till the amount of 4 dr. was reached. The sensations experienced from 40 min. to 3 dr. were those of moderate alcoholic stimulation, slight pain through the frontal region, and a buoyancy and lightness of feeling rather agreeable. . . . In the pulse-traces, additional force is manifest in the heart's action in all cases, and in the general appearance of weakly persons placed on acid treatment the same fact is apparent—the congestion of the extremities and lips has soon given place to a more natural colour" (Amer. Journ. of Insan., Oct., 1869).

Nervous System.—Dr. J. B. Andrews and many others find phosphoric acid to be a powerful nerve-tonic, but the conclusions are founded more upon clinical observations on depressed persons than on the healthy. "Moderate doses produced on the latter the feeling of buoyancy and exhilaration already mentioned, but larger quantities caused a feeling of drowsiness, an inclination to lie down, and unwillingness for mental labour." The acid exerts also a marked control over the vaso-motor nerves, and through them improves the tone of the circulation. Hecker and Burdach concluded that phosphoric acid acts more than any other on the nervous system, heightening excitability in a great degree. Sundelin asserted that this action is directed especially to the genital organs, and although neither Neligan nor Andrews could verify this, I have myself noted it in sixteen patients, who had no knowledge of the supposed aphrodisiac quality of the drug; they all complained to me of such effects in greater or less degree.

Digestive System.—Moderate doses tend to improve the tone and functional power of the stomach, and as already remarked, this acid irritates much less, even after continued use,

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than the other inorganic acids; large or concentrated doses, however, taken by the mouth, may cause gastro-enteritis, and after death, redness, erosion, and ecchymoses have been found in the stomach and duodenum (Monk and Leyden). When Pavy injected 1 to 2 oz. into the stomach of dogs it was quickly rejected, but on passing it into the duodenum, a saccharine condition of the urine and the blood was produced, just as after intravenous injections. After toxic doses, fatty degeneration has been found in the liver, kidneys, and muscular tissue.

SYNERGISTS AND ANTAGONISTS.—The same as for other mineral acids (*v.* p. 252).

THERAPEUTICAL ACTION.—*Internal.*—**Nerve-Debility.**—The therapeutical influence of phosphoric acid is mainly exerted on the nervous system, and in the treatment of nerve-debility acts much like iron in anæmia, as a chemical food supplying something actually deficient in nerve-nutrition. When mental effort has been protracted till a sense of weariness renders its continuance difficult, a dose of the acid, from its stimulant effect, relieves fatigue, and seems to invigorate the mental powers, and prepare the mind for renewed exertion.

Dr. J. Andrews, describing a case of impaired mental power from excessive brain-activity, observes, "The patient is languid, unable to do mental work with the usual facility, nervous, and at times fearful, timid, and agitated, the memory weakened, and permanent impairment threatened. Such cases have been termed 'cerebral paresis,' but for their recovery, relaxation from business, and phosphoric acid, with some suitable tonic, generally suffices."

Of more serious conditions, such as dementia following acute mania, Dr. Andrews remarks, "This is a period of nervous exhaustion, of reaction from the increased mental and physical activity which marked the previous state of the disease; tone and vigour must be supplied to the prostrated system, and for this phosphoric acid is of material service." It relieves peripheral congestions connected with impaired tone of vaso-motor nerves, and in weakened relaxed conditions akin to impotence, and resulting from sexual excess, it has proved a special help.

Fever.—In any fever where the nervous system is specially

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depressed, phosphoric acid is indicated; it assuages thirst, and helps to remove exhaustion; its pleasant taste is one advantage over the other mineral acids.

Stromeyer, and others, recommend it in "eruptive fevers." The following is a convenient form:—℞ Acidi phosphorici diluti, fl. ʒiij.; glycerini, fl. ʒj.; decocti hordei, Oij.: mix, and use when cold as a common drink.

Diabetes.—Phosphoric acid often relieves the thirst of this malady, and has been recommended by Latham, Paris, Watson, and other practical physicians; on the other hand, the experiments of Pavy (already quoted) indicate that much of it would be injurious, and Griesinger not only states that it does not lessen the excretion of sugar, but in one case supposes it actually to have caused the malady.

Against this, we might set a case recorded by Thornley, in which the thirst was relieved and the patient apparently cured (Med. Press, May 20, 1868); but without being in a position to dogmatize on the matter, I may say that I have known the acid on several occasions to relieve symptoms and diminish the amount of sugar in the urine.

Urinary Disorder.—In phosphatic deposits connected with waste of nervous tissue, and in alkalinity of urine with nerve-depression, phosphoric acid is very useful, and it has relieved the symptoms of phosphatic calculus and urethro-vesical catarrh, when nitric and hydrochloric acids had failed. Benefit has also been derived from it in *oxaluria*.

In **Rachitis**, the milky phosphatic condition of urine is cleared by the acid, though Dr. H. Wood considers that the phosphates act better.

Phthisis—Struma.—In these conditions generally, phosphoric acid fulfils many indications as a grateful moderately astringent tonic; it relieves hoarseness and dry irritating cough accompanied by pain and laryngeal soreness. Dr. Cotton gave it to twenty-five patients with chronic uncomplicated phthisis at Brompton Hospital, and observed benefit in a few advanced cases: it improved appetite and controlled secretion, although sometimes nausea and pain were excited: he could not trace a specific effect from it, but rather the action of a general nerve-tonic; it acted specially well combined with iron (Med. Times,

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i., 1863). Dr. C. J. B. Williams recommends it with cod-liver oil (Lancet, ii., 1868, p. 213).

In the *dyspepsia* so common in phthisis, it is also useful, relieving the pain, sickness, and diarrhœa which occur after meals. Profuse night-sweats and other exhausting discharges are controlled by it, and it exerts a sedative effect upon the excessive sexual desire which often developes in some stages of phthisis. Dr. Todd used it in cardialgia.

Hæmoptysis—Hæmorrhage.—M. Hoffmann has written to specially recommend this acid in hæmoptysis; and the main reasons for his preference of it would seem to be its "less corrosive action," and better toleration by the stomach, otherwise its stimulant powers would make it less generally suitable than sulphuric acid; he gives 10 to 30 drops in mucilage (Journ. de Chim. Médic. June, 1868). I have myself seen good results from the acid in purpura and passive hæmorrhage, also in metrorrhagia.

Strumous Conjunctivitis.—This malady is often troublesome, not so much from its severity, as from its persistence and great tendency to relapse, and Mr. Balman has written to praise phosphoric acid, not only in struma, but specially "in the intermittent ophthalmia of a scrofulous constitution:" he says that, given in doses of from 5 to 20 min. in calumba, the acid both cures and prevents recurrence of the affection (Lond. Med. Gaz., Aug. 22, 1858).

Scorbutus.—Liebig and others have held that the scurvy of sailors is mainly owing to the exclusion of phosphoric acid from their diet, since in the ordinary preparation of meat for sea-stores the greater portion of the acid is extracted from it, and the complaint has been cured by giving food containing the acid, although the sailors continued to use the salted beef to which scurvy was attributed (Letters on Chemistry, p. 425). Professor Galloway has verified the presence of phosphoric acid in lemon-juice, and hence, according to Morgan and Neligan, its superiority to citric or tartaric acids, but I am not aware that the theory has been largely tested in practice.

Bone-Diseases—Caries.—In caries, M. Leutin applied dilute phosphoric acid to the affected bone with the idea of supplying a deficient element, and practically this sometimes

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relieves and improves the bone-condition. Its good effect is, however, better seen from internal administration, especially if much hectic be present. It is said to be also beneficial in cases of unusual depositions of phosphate of lime, as in exostosis, and bony tumours generally (Neligan, Garrod). Wormald states that the detection of phosphoric acid in pus is diagnostic of necrosis (Lancet, ii., 1862, p. 440).

In Rachitis I have found it a useful medicine, and it relieves the diarrhœa and sweating of that disorder.

Diarrhœa.—Phosphoric acid is suitable for cases of diarrhœa when an acid is indicated. Sedgwick strongly recommends it for choleraic cases, and argues for its use in true cholera (Lancet, ii., 1871, p. 280).

PREPARATION AND DOSE. — *Acidum phosphoricum dilutum:* dose, 10 to 30 min. freely diluted.

ACIDUM SULPHURICUM—SULPHURIC ACID—OIL OF VITRIOL, H_2SO_4, = 98.

This occurs native in the water near volcanoes, as in Java, and in the "Sour Springs" near the Erie Canal. It is found in combination in twenty-two natural sulphates, also with ammonium in rain-water, near towns. It contains 79 per cent. of anhydrous sulphuric acid, SO_3.

There are two other forms of the same acid, *the acidum sulphuricum dilutum*, and the *acidum sulphuricum aromaticum*, which are weaker by one-seventh than the first-mentioned.

PREPARATION.—By passing sulphurous acid gas (sulphurous anhydride) into leaden chambers, and bringing it there into contact with steam and nitrous fumes (nitrous anhydride); from the latter it absorbs an atom of oxygen, becoming sulphuric acid (anhydrous), and this combines with water to form a dilute sulphuric acid, which is afterwards concentrated up to a sp. gr. of 1·843; a small quantity of nitric oxide gas will act as a

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carrier of oxygen from the atmosphere to a large quantity of sulphurous acid. In chemical formulæ the main reaction may be represented as follows:—

$$SO_2 + H_2O + N_2O_3 = H_2SO_4 + 2NO.$$

CHARACTERS AND TESTS.—The pure acid is an oily-looking, colourless liquid, but the commercial acid is often dark-coloured from contained fragments of organic matter, which are charred by the acid. It has an energetic affinity for water, which it absorbs readily, so that a partially-filled bottle of acid, if exposed to the air, will, after a time, overflow; if quickly mixed with water it undergoes condensation, and much heat is evolved. A very small quantity of sulphuric acid, or of any soluble sulphate, can be detected by adding to the diluted solution a little chloride of barium, which gives a dense white precipitate, insoluble in acids.

ABSORPTION AND ELIMINATION.—Moderate doses of the dilute acid are readily absorbed, either as sulph-albuminates (Orfila), or, after combining with bases in the gastric secretion, as sulphate of potash or soda (Miguel): very small doses only in the latter form (Husemann).

The dilute acid forms with albumen both a soluble, and an insoluble compound according to the degree of dilution—the former resulting from quite weak acid (Berzelius). That dilute sulphuric acid may be absorbed through the *skin*, follows from the experiments of Lebküchner, who induced acid reaction of urine and fæces by applications to the abdomen of rabbits.

Gubler teaches that this, like the other mineral acids, circulates in the blood, but loosely combined with albumen, and that on reaching the emunctories the combination breaks up, albumen remaining in the vessels, whilst the acid passes out with the excretions, combining with the bases therein found.

It has been a question whether after poisonous doses, the acid may be absorbed and remain free in the blood, leading to its coagulation. Geoghegan states that after 1½ oz., when a woman survived thirty-one hours, he found traces of acid in the pericardium and in the kidney, not in the blood, but in that fluid he found much *phosphoric* acid, derived, he suggested, from phosphate of soda from which sulphuric acid had displaced it

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(Med. Gaz., xl). In another case Dr. Walker found a trace in the cerebral fluid and in the cardiac blood (Edin. Journ., 1850). Casper found the blood and serous fluids acid, and Carus states that he found sulphuric acid in all the organs of a fœtus, after a fatal dose taken by the mother (Beck's Jurisprudence, ii., p. 429). More recent researches state that mineral acids cannot be detected free in the blood, and that its reaction cannot be rendered acid consistently with life (F. Walter; *v.* Hydrochloric Acid). It is not likely that the coagula described by Bouchardat in the great vessels were really due to direct action of free acid,—Taylor could find no trace of it in similar coagula (On Poisons, p. 31).

The acid is *eliminated* by the urine, and according to Dr. Letheby, very quickly after full doses (Med. Gaz., xxxix., p. 116). Most observers agree that it cannot be found free in that secretion, but as sulphate (Bence Jones), and the heightened acidity is really due to uric and lactic acids displaced by the stronger sulphuric acid from their ordinary combinations. Seeing the comparatively small amount of sulphuric acid accounted for in the renal secretion, Headland suggested that some passed by the lower bowel and the skin, and this is probable.

PHYSIOLOGICAL ACTION.—*External.*—The dilute acid, applied to the skin, causes some burning pain and pallor, followed by redness; more concentrated, it destroys the epithelium, changing it into a firm brown mass. It coagulates albumen, and disintegrates horny tissues with formation of leucin and tyrosin. In its full strength, it causes destruction and sloughing of any tissue by virtue of its strong affinity for organic bases, as well as for the water with which they are combined. The acid has disinfectant and antiseptic powers, and destroys infusorial life.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Very small doses give a characteristic markedly acid taste, and lessen the sensation of thirst; 10 to 15 min. of the dilute acid, administered several times at intervals, stimulate the appetite and exert some astringent effect on the gastric and other secretions. If continued, however, the medicine induces dyspepsia with acid eructation, colic, and even diarrhœa, which

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may be due to the large amount of alkaline sulphates formed, as well as to direct irritation.

The local symptoms induced by *toxic* doses of the strong acid are very severe; intensely acid pungent taste is followed by acute burning pain in the mouth, pharynx, and stomach, and violent retching and vomiting, the ejecta usually containing dark blood; there is extreme thirst and great sense of distress —sometimes purging with tenesmus. The faucial inflammation may induce suffocation, angina, or laryngeal œdema, and thus prove fatal early in the case, or peritonitis may be set up, and if death do not occur from collapse, it may follow on perforation of the œsophagus, stomach, or bowel in twelve to forty-eight hours after the poisonous dose; should life be saved for the time, the inflammation of the alimentary tract is likely to be followed by serious contraction, etc.—swellings, and suppuration of the parotid glands may occur. Any slough produced by this acid is black in colour.

Circulatory System.—Bobrick found, with frogs, that this acid, given by the stomach, or applied to the skin, caused the heart to act more slowly, and finally stopped it in diastole. Hertwig, experimenting on mammalia, found that moderate doses of the dilute acid lowered the pulse-rate and the temperature, whilst arterial tension was increased. I am not aware that similar results have been verified on the healthy human subject, nor has proof been given of the acid's power to lower temperature in febrile conditions. It has been said by some that the blood becomes less, by others more coagulable, but its exact state is not ascertained; nor do we rightly know whether the smaller vessels are contracted or not by the acid (Nothnagel; *r.* p. 294). When injected into the veins it causes instant death from coagulation of blood and thrombosis, and the corpuscles are altered or destroyed by toxic doses taken internally.

In cases of poisoning by the acid, the disturbance of circulation is mainly secondary to the gastric irritation: there may be faintings, passing on to actual syncope or collapse, the pulse becoming later rapid and small, the extremities icy cold, and respiration laboured and superficial.

Nervous System.—Ordinary doses do not produce other than tonic effects upon this system. In fatal cases of poisoning, the

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mind is generally clear or but slightly clouded; exceptionally, coma has developed.

Glandular System.—Most of the secretions become more acid under the free use of this drug, and some of them, especially those of the skin and the bowel, are lessened in amount. Bobrick, however, found the quantity of urine and the amount of urinary sulphates increased by it. After large doses, Leyden and Munk distinguished different conditions corresponding to different alterations in the kidney; finding albumen alone, or with epithelial casts, or with fatty globules and epithelium, or in addition, hyaline casts, and blood- and pus-corpuscles.

PATHOLOGICAL CHANGES.—The anatomical lesions found in the stomach after death vary according to the concentration of the acid, and the duration of its effects. In milder cases, the epithelial and the upper layer of the rete mucosum are shrunk, parchment-like, and greyish: in the severest, the whole tissue is mortified, blackened, and changed into a soft gangrenous mass. Fatty degeneration of different organs has also been lately described as a constant result of poisoning by sulphuric acid, and particularly in the liver, the striped muscular tissue, the heart, and the renal epithelium. This change is to some extent explained by the destructive action on the red corpuscles, which are in part destroyed, and in part altered, becoming smaller, darker, and of granular appearance, and certainly unequal to their proper function; hence the tissues are imperfectly nourished, and readily degenerate. The same alteration in the oxygen-carriers explains the lowered temperature, the feeble pulse, and the general debility, as well as the functional albuminuria from excretion of constituents of the altered blood-cells.

SYNERGISTS.—The other acids and cooling remedies are allied in action, and as regards styptic effects, ergot and astringents generally, are auxiliaries.

ANTAGONISTS—INCOMPATIBLES. — Warm stimulating remedies and "fluidifying" medicines, such as mercury and iodides, antagonize some of the effects of sulphuric acid. Alkalies and bases are chemically incompatible. The best antidotes in a case of poisoning are magnesia, chalk or white-

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wash, and soap, which should be given in albuminous solutions, such as milk and water. Alkaline carbonates are considered not advisable because they form irritant compounds (Christison); also they evolve much carbonic acid, but may be used in cases of emergency. Oil to protect the mucous membrane of the stomach is also very useful.

THERAPEUTICAL ACTION.—*External.*—The highly caustic property of strong sulphuric acid is utilized comparatively seldom on account of the difficulty of restraining it within due limits.

Chancre—Gangrene—Cancer.—In chancre, with phagedænic ulceration, Ricord recommends a caustic paste made with sulphuric acid and charcoal to be applied on linen for several hours—until a slough forms. In hospital gangrene the pure acid has been successfully employed (Med. Times, i., 1859). For such purposes and for cancer, Sir J. Simpson mixed it with zinc sulphate. The reason for using powders, especially charcoal, to mix with the acid, is to secure a full strength in convenient form without dilution with water: Syme employed sawdust, Velpeau, saffron.

Caries—Necrosis.—It is evident that a lotion containing mineral acid will dissolve out the earthy bases of bone-tissue and quicken disintegration, and for this purpose it has been applied to some extent in surgery. Chassaignac recommended dilute hydrochloric acid, but more recently Mr. Pollock has brought forward much evidence in favour of the application of sulphuric acid mixed with an equal part of water, "for the more speedy removal of dying bone, or more rapid separation of dead portions, or destruction of the surface of carious cavities;" he finds it simple and safe, and comparatively painless—nor has he ever seen bad consequences from it. His first case, one of necrosis of cranial bone, was touched daily with the dilute acid,—the diseased part quickly separated, and healthy granulations formed. Cavities may be filled with lint soaked in acid, and when this is removed in two or three days, an opaque white layer may be seen and taken away; this is a slough, soft owing to removal of earthy particles, which may be found lying loose in the wound: any pain caused by the caustic

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ceases in a short time because the acid is soon neutralized. In some flat bones, such as those of the trunk or pelvis, the undiluted acid may be cautiously used. Recovery may be secured "in weeks instead of months" under such treatment, though it will not always succeed without operative interference (Lancet, i., 1870). W. Hayward, H. Marsh, and others, have also recorded good results from the practice recommended by Mr. Pollock.

Ectropion—Entropion.—In these deformities of the eyelids, sulphuric acid has been used by Laurence to cause a linear cicatrix, which, by its contraction, shall restore the natural position of parts, but other methods of cure are preferable.

Poisoned Wounds.—This, like the other mineral acids, when employed to cauterize poisoned wounds, bites, etc., has the advantage over solid caustic of more penetrating power. W. Frazer considered strong sulphuric acid better than any other (Materia Med., p. 12).

Parasitic Skin-Diseases.—In ringworm and in scabies, an ointment containing 1 dr. of acid to the oz. of lard has sometimes proved useful, though irritating; for the latter malady it is said to be largely used in the Prussian army (Neligan).

Pruritus. — In prurigo, lichen, and chronic urticaria, disorders attended with violent itching, a lotion containing 1 to 3 dr. of dilute acid in 8 oz. of water often relieves. Pereira says that its internal administration is also efficacious.

Angina.—For relaxed surfaces coated with tenacious mucus dilute sulphuric acid is an excellent cleansing astringent: hence it is in constant use as a *gargle* (1 to 2 dr. in 8 oz. of infusion of roses) for relaxed uvula, etc.; in weaker proportion it is also suitable for scarlatinal throat. The addition of 2 dr. of alum to the gargle often greatly increases its value.

THERAPEUTICAL ACTION.—*Internal.*—It is commonly said that for digestive disorders requiring an acid, hydrochloric is the best: to stimulate hepatic and intestinal secretion nitric acid is indicated, whilst the astringent effect of sulphuric is of special value in controlling sanguineous and other discharges.

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Hæmorrhage.—Sulphuric acid was formerly in very frequent use as an internal remedy for hæmorrhage, especially of passive character, whether from the stomach, lungs, or uterus. That there is difficulty in explaining how it can exercise astringent effect after dilution and possibly combination in the blood, would be no argument against its use if this were *proved* efficacious; but my experience is the same as that of many modern observers (amongst whom I may mention Nothnagel and H. C. Wood), who give to sulphuric acid a *secondary* place amongst hæmostatics, although I have known it succeed *sometimes* when other remedies have failed.

Diarrhœa.—Dilute sulphuric acid has a well-deserved reputation in various forms of intestinal flux, and especially in summer diarrhœa of choleraic character: it often answers well, but when given alone I have sometimes found it aggravate the disorder, whether by irritation or by increasing the acidity of secretions: the aromatic sulphuric acid should then be preferred in combination with some preparation of opium.

In diarrhœa, with coated tongue and evidence of biliary disorder, the acid has acted admirably with small doses of magnes. sulph., tinct. rhei., and aqua chloroformi: it is a good remedy for children.

Cholera.—Dr. Curtin has recorded that a severe epidemic in an institution under his direction ceased within twelve hours after the inmates were treated freely with "sulphuric acid lemonade"—the only fresh case occurring in a man who refused to take the medicine. Two days after it was discontinued two new cases appeared, and an epidemic threatened, but was again stayed by the acid, and in the surgical wards where the acid was used from the first, no case appeared, whilst every other part of the institution suffered more or less (Philadelph. Med. Times, iii., p. 649). This experience makes it desirable under similar circumstances to adopt the same method as prophylactic.

Fever.—In the diarrhœa of enteric fever, H. Kennedy, Murchison, and other authorities advocate the use of sulphuric acid (*v.* p. 254). We do not expect from it, as formerly, a power of shortening the morbid process; but it will allay thirst, and, to some extent, moderate the pyrexia and the undue secre-

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tion. In any enteric cases, the dose used should be small and well diluted: the aromatic, I find preferable to the simple form.

Pyrexia—Phthisis.—Whether sulphuric acid does or does not lower pulse and temperature in the usually employed doses, it certainly is of more service in secondary pyrexial states than in specific fever. In subacute inflammatory conditions of protracted character occurring, *e.g.*, during caseous pneumonia or chronic phthisis, it alleviates the general symptoms, and sometimes the local conditions. It is well suited for phthisical cases with a tendency to undue discharges, for it acts as a grateful tonic and astringent, lessening the night-perspirations, the intestinal flux, the expectoration, and passive hæmoptysis; by combination with opium, or belladonna, aromatics, etc., so much relief may be sometimes given as to merit for the remedy its old title of "Elixir Vitriol."

The presence of cough does not contra-indicate its use, but irritation of the fauces must be obviated by mucilage or syrup: acids should, however, be omitted if gastric irritation be excited by them.

Palpitation.—Nothnagel recommends this acid, combined with laxatives, in the palpitation of plethoric subjects; it is not indicated for the anæmic or chlorotic, nor specially useful in the palpitation of valve-disease.

Lead-Poisoning.—Since the publication of the cases of M. Gendrin and Dr. H. Bennett in 1846, the acid has had more or less reputation as an antidote and prophylactic in poisoning by lead; but modern observation does not quite corroborate their estimate of it. Tanquerel especially failed to obtain any good results (Maladies de Plomb, ii., p. 497); on the contrary, the use of an acid lemonade seemed to make the workmen rather more liable to colic.

PREPARATIONS AND DOSE.—*Acidum sulphuricum—Oil of vitriol:* is not used internally except in the following:—*Acidum sulphuricum aromaticum:* dose, 5 to 30 min. freely diluted. *Acidum sulphuricum dilutum:* dose, 5 to 30 min. freely diluted. An alkaline mouth-wash should be used after taking the acid, or a little butter placed on the teeth before.

ADULTERATIONS.—The usual impurities of this acid are salts, nitrous oxides, arsenic, and lead.

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ACIDUM SULPHUROSUM—SULPHUROUS ACID,

SO_2, = 64.

The pharmacopœial sulphurous acid is a solution of the gas in water, containing 9·2 per cent. by weight = twenty times its volume.

PREPARATION.—By deoxidizing sulphuric acid by distilling it with coarsely-powdered wood charcoal. The carbon combines with part of the oxygen of the acid to form carbonic acid and probably carbonic oxide, whilst sulphurous acid gas (anhydrous) passes over into a receiver containing distilled water, being previously washed from sulphuric acid and other impurities.

$$2C + H_2SO_4 = CO_2 + 2H_2O + 2SO_2$$

CHARACTERS AND TESTS.—A nearly saturated solution of sulphurous anhydride, SO_2, colourless, of strong suffocating odour and pungent acid taste, which, however, is not unpleasant in moderate dilution. It bleaches vegetable colours, and is an energetic oxidizing agent: it is said to absorb radiant heat in a high degree (R. Bird). The hydrated acid can be obtained in crystals, but is very unstable. A solution of the officinal strength and upwards oxidizes on exposure to light and air (*e.g.*, when kept in partially-filled transparent bottles), with formation of sulphuric acid—an important change, since the special properties of the drug are thereby impaired or lost; contact with chlorine at once induces this change. It should therefore be carefully kept; or better still, be freshly prepared when wanted. Water would absorb forty or fifty times its bulk, alcohol still more; but Professor Redwood recommends a 5 per cent. solution, as more easily made and more stable than that of the B.P.

Tests.—1. When evaporated, it should leave no residue. 2. Barium chloride gives a copious white precipitate (of barium sulphate) if sulphuric acid be present. 3. Sulphurous acid decolorises a solution of iodine with formation of hydriodic and sulphuric acids, thus—

$$SO_2 + 2H_2O + I_2 = H_2SO_4 + 2HI.$$

3·2 gr. sulphurous acid neutralize 12·7 iodine.

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Of the gas, 1 part in 100,000 of air is perceptible to the nose; 9 parts are disagreeable and provoke cough; 20 parts are irritating, and 43 parts (= 4 parts in 10,000) are irrespirable: much less than this will kill plants (Letheby, loc. cit.). In generating it by burning sulphur in air, 32 parts by weight combine with an equal quantity of oxygen to produce 64 parts of sulphurous anhydride, which occupy precisely the same bulk as the oxygen consumed. Its density is high, the sp. gr. being 2·247; a cubic foot weighs about 1,206 gr., and to produce it 603 gr. of sulphur and a cubic foot of oxygen (= 5 cubic feet of atmospheric air) are requisite (Letheby, Med. Times, ii., 1873).

Alkaline sulphites and *hyposulphites* owe their properties to the sulphurous acid liberated from them, and although not officinal are often prescribed.

Sodæ Sulphis—Sulphite of Soda.—Prepared by saturating a solution of carbonate of soda with sulphurous acid gas, and crystallizing. It occurs in white efflorescent prisms which have a slight alkaline reaction, and the odour and taste of sulphurous acid; soluble in cold water (1 part in 4), and in less than 1 part boiling water.

Sodæ Hyposulphis—Hyposulphite of Soda (*Appendix B.P.*).—Prepared by gently warming a solution of sulphite of sodium with finely-powdered sulphur, or by passing sulphurous acid gas through it. Occurs in colourless crystals (oblique rhombic prisms); bitter, slightly alkaline, and sulphurous in taste, less unpleasant than the sulphite. Very soluble in water, not in alcohol; decolorises iodine solutions, and dissolves salts of silver which are commonly insoluble, *e.g.*, the chloride. A solution of hyposulphite is distinguished from one of sulphite by the precipitation of sulphur on adding sulphuric acid. Hyposulphites do not act on iodide of potassium.

Potassæ Sulphis—Sulphite of Potash.—Prepared by saturating a solution of potash carbonate with sulphurous acid gas, and crystallizing. It occurs in white opaque fragments or powder, with slight odour of the gas—very soluble in water (1 in 3). Taste saline and sulphurous.

Magnesiæ Sulphis—Sulphite of Magnesia.—Contains proportionately more of the acid (gas) than any other; it is also the most soluble, and the least unpleasant (Polli).

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Calcis Sulphis—Sulphite of Lime.—Is soluble only in 800 parts water, but the bisulphite and hyposulphite are freely soluble.

ABSORPTION AND ELIMINATION.—*Sulphurous acid* is readily absorbed, and its characteristic odour has been observed in the breath and secretions after its administration (Dr. Geo. Wilks, B. M. J., ii., 1870). It passes out also with the urine and fæces as sulphate or sulphuric acid, for it is readily oxidized in the system.

The sulphites are decomposed in the stomach by the gastric acid, sulphurous acid is given off, and they are mostly changed into sulphates (Kletzinsky), and are eliminated as such, partly by the intestinal canal, but chiefly by the kidneys (Bartholow); they pass within twelve to twenty-four hours after administration (Polli).

The hyposulphites undergo similar changes, but more slowly, for they are more stable.

After very large doses, these salts may be found unchanged in the urine (Rabuteau), and after their application to wounds, free sulphuric acid may be traced in the same secretion (De Ricci).

PHYSIOLOGICAL ACTION. — *External.*—Externally applied, sulphurous acid is refrigerant, somewhat astringent, and in full strength irritant. The most important property of the gas and its compounds is that of arresting fermentation, and of destroying the lower forms of vegetable and animal life, and certain infective organic poisons. Its power of controlling ferments and destroying visible *parasites* is readily proved, but its action on infectious organic *particles*—a true "disinfectant" action, by which they are rendered inert—is not so capable of demonstration, because the poison itself, the essence of infection, has not yet been verified and isolated; still, as Dr. Sansom observes, "we know that such poison is ponderable, that it obeys physical laws, and is active for long periods, though so minutely divided as to be undemonstrable by ordinary direct physical means" (B. M. J., ii., 1872). The diffusion-experiments of Chauveau and Sanderson have proved, at least for vaccinia, variola, and sheep-pock, that the poison is solid, insoluble, and indiffusible; and to judge from

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its effects, its extraordinary power of multiplication, etc., either it must have some properties of living matter, or act by a process of catalysis or fermentation: the former seems more likely, but however it be, if we make evident that sulphurous acid can prevent or arrest the development of the bacteria, monads, and germs of fungi, etc., which accompany decomposition, it is by analogy probable that it can exert a similar effect on the minuter particles which constitute infective poison. In proof of the former fact, amongst other experiments, Dr. Sansom placed cubes of egg-albumen under glass covers with solutions of permanganate, of aluminium chloride, of carbolic and sulphurous acids; and with the two latter agents, notably with the last, secured almost complete preservation, even after the admission of air (B. M. J., loc. cit.). For aerial disinfection Hoppe-Seyler, after careful trial, found sulphurous acid gas the best agent,—1 or 2 per cent. of it in the air of a room destroying all the lower organisms: this could be secured by burning ½ to 1 dr. of sulphur for each 100 cubic feet of space (Lancet, ii., 1871, p. 304).

Letheby arrived at similar conclusions, but recommended, for greater security, a larger proportion of sulphur—1½ oz.—to each 100 cubic feet of air (Med. Times, ii., 1873).

Dr. Baxter, taking up the same question from another point of view, concluded not only that sulphurous acid was the best of aerial disinfectants, but that its action on vaccine virus was more potent than that of chlorine or carbolic acid. Thus he vaccinated one arm of a child with points of virgin lymph, and the other arm with points previously exposed to the action of the three agents, and whilst small vesicles often resulted after the use of chlorine or carbolic acid, *none* could be obtained after sulphurous acid, "even under conditions which seemed to render the virulent particles least susceptible to destructive influences" (Sixth Report of Med. Off. Privy Council, N. S., and Lancet, i., 1876). It is true that Dr. Dougall had found sulphurous not so effective as other mineral acids (notably chromic acid) in preventing the decomposition of organic solutions, but Crace Calvert showed this was not correct, and 1 part of the former in 1,000 of albuminous solution was enough to preserve it for forty days, whilst other acids only preserved it for nine or ten days.

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Dr. Fergus also compared glasses of beef extract heated with sulphurous acid, carbolic acid, and terebene, and found several weeks afterwards that the one heated with sulphurous acid remained quite sweet whilst the others were decomposed (Practitioner, i., 1877).

PHYSIOLOGICAL ACTION.—*Internal.*—From the preceding and many other observations, there can be no doubt of the disinfectant power possessed by sulphurous acid in a very high degree when brought into *direct* contact with infective or putrescent material, whether in the air, or in wounds, etc., but the further question whether it can be so introduced into the circulating blood of living animals as to neutralize a septic poison therein also circulating, or so as to prevent the admission of such poison, is more difficult to resolve. Dr. Polli (Milan) held the affirmative to be proved by his experiments upon dogs with sulphites and hyposulphites; after treating an animal with these medicines, he injected septic poison, and found it did not succumb to the effects, whilst a healthy but untreated animal quickly did so. In other cases, examining the bodies of animals killed after sulphite treatment, they were found to decompose much less quickly and less readily than others not so treated. He offered, also, some clinical evidence of the value of these remedies in septicæmia, and much practical benefit was expected from his observations; they have not, however, yet passed the region of controversy. Semmola, O. Weber, and others, deny them, or characterize them as "negative." Clinical results differ, and although I hold that much may be done by introducing "disinfectant" medicines, especially sulphurous acid, into the organism, I acknowledge that definite proofs of their power and mode of action within it are still to be desired (*v.* p. 314, also Carbolic and Salicylic Acids).

Digestive System.—Sulphurous acid solution may be taken internally in moderate doses and well diluted without definite effects on the healthy body, unless it be the quenching of thirst and some refrigerant action. Insufficiently diluted, the solution excites local irritation of the digestive tract, some persons being more sensitive to this than others. The sulphites and

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hyposulphites in large doses increase peristalsis, and cause purging, though not so readily as sulphates.

Temperature.—Given during the pyrexial state, *e.g.*, of remittent fever, sulphurous acid is said to lower the body-temperature.

SYNERGISTS.—Disinfectants and antiseptics generally, aid the action of sulphurous acid, but it is so readily oxidized that it is better used alone. Steam favours the aseptic action of the gas, and nitre added to the burning sulphur makes it more effective (Dewar).

ANTAGONISTS.—All oxidizing substances alter the chemical constitution of sulphurous acid, and impair the peculiar properties of sulphites, especially when in solution. The mineral acids, including sulphuric, decompose sulphites and hyposulphites.

THERAPEUTICAL ACTION.—*External.*—**Parasitic Skin-Disease — Favus — Ringworm.**—Sulphurous acid solution is a cleanly and efficient mode of treating these maladies, as first pointed out by Sir William Jenner (Med. Times, ii., 1853, p. 181). It may be painted on occasionally in full strength, or used in lotion or compress, 1 part to 2 or 4 of water and glycerine—the great point is to secure its thorough contact with the diseased surface.

Pityriasis Versicolor (Chloasma).—A weaker lotion than the last-mentioned, 1 part in 8, or one containing sulphite or hyposulphite of soda (℥j. in ℥viij.) will cure this disorder.

Pruritus Vulvæ, etc.—When pruritus is dependent on discharge, or other source of irritation, possibly parasitic, injections and lotions containing "bisulphite of soda" (gr. xv. ad ℥j.) have been found serviceable (Lancet, ii., 1871, p. 454). The itching of lichen and of true prurigo senilis may also be relieved by lotions containing sulphites.

Erysipelas.—A sulphurous lotion will often give great relief to the burning pain of erysipelas, and its constant application is said to cut short the malady. Dr. Hewson records twenty-seven cases of various degrees of severity—seven of them idiopathic.

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and all treated by the local use of a sulphite lotion (sodæ sulphitis gr. x. ad ʒj.) applied on lint covered with oiled silk; it bleaches the skin and "destroys the inflammation" (Philadelphia Med. Times, i., 1868). Mr. Pairman describes great and immediate relief to pain in a severe case of facial erysipelas from a lotion of equal parts of glycerine and sulphurous acid: the patient recovered at the end of a week, but tincture of steel and other remedies were given internally; relief, however, was clearly traceable to the lotion, and it deserves to be more generally used than it is at present.

Chilblains—Corns—Fissured Nipples, etc.—For these minor, but annoying ailments, sulphurous acid is a good remedy. Mr. Pairman applies the strong solution of the acid on lint covered with oiled silk: if the skin be broken, the acid should be diluted. Sore nipples are to be "soaked well with strong acid for a few times" (Pamphlet, The Great Sulphur Cure, 13th ed., 1868). Mr. Fergus applies the acid in spray to chilblains, or uses as a wash 3 parts of the solution to 1 of glycerine and 1 of water (Lancet, ii., 1870, p. 769).

Bruises—Sprains.—The same surgeon, who speaks from good experience at Marlborough College, has found a lotion containing sulphurous acid very useful in "every kind of bruise and sprain." He recommends a spray of pure acid for six or seven minutes till the part feels cold, then lotion (1 in 8) to be applied and frequently changed; in forty-eight hours inflammation and pain have subsided, and on the third or fourth day the limb can be strapped or bandaged.

Wounds—Fractures.—Mr. Fergus records also excellent results from the acid used in lotion to a compound fracture and to a severe contused wound of the face (where it is always important to avoid scarring): under a lotion of 1 part in 7 constantly applied, the wounds healed quickly and without suppuration. Dr. John Balfour has had marked success with a lotion (1 in 12) applied on *thin* rag kept constantly wet for the first day or two after injury, afterwards wetted every twelve hours with tepid lotion kept covered by oiled silk, zinc ointment being substituted about the third or fourth day. Severe compound fractures of the hand with laceration of tendon, and gunpowder burns,

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fractures of the shoulder and other joints by machinery—all did well under this treatment, which seemed to give almost instant relief from pain, to control and greatly restrain suppurative action, and secure primary union whenever possible. (Edin. Med. Journ., June, 1869, Nov., 1871). Mr. Pairman notes its value in quickly curing a "hack" in horses.

Ulceration — Gangrene. — In cases of unhealthy open wounds, and even hospital gangrene, sulphurous acid has sometimes proved more efficacious than carbolic; this was especially seen in hospitals at Metz during the Franco-Prussian war (Med. Times, ii., 1871, p. 358).

Angina.—In various forms of sore throat, sulphurous acid in gargle, or preferably in fine spray, is exceedingly useful, relieving pain, lessening inflammation, destroying parasitic growth, and cleansing unhealthy suppurating surfaces. It is, in my experience, of great value in *aphthous* conditions such as occur during phthisis or other exhausting diseases, as well as in the ordinary form common during infancy; it often relieves the pain, tension, and ulceration of scarlatinal and variolous throats, and I have seen it of the greatest service in chronic syphilitic ulceration of the fauces.

In the acute inflammatory stage of catarrhal angina, it is not always well borne, but will be found to answer better in such cases when used of full strength, if only for a very short time, than if diluted; in the latter case, it has seemed to irritate the mucous membrane without controlling inflammation, but there is no *one* rule, a short trial will be the best guide; young children do not usually bear it well. Fergus, on the other hand, says it is good "in all forms of inflammation of the throat and tonsil;" it should change the turgid redness to a light pink during the application.

Dysphonia Clericorum—Follicular Pharyngitis.—Dr. Dewar has published cures of this condition, so rapid and after so many years' duration of the malady, as to border on the marvellous. One clergyman, a sufferer for twenty years, found immediate relief from the spray—"something loose, feeling braced up;" and others suffering also from general weakness, night-sweats, nervousness, partial aphonia, etc., are said to have been restored by sulphur fumes and spray. The cases are de-

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scribed in popular language rather than with scientific accuracy, but we may accept the fact of much relief being afforded in the class of maladies referred to (Med. Times, i., 1867, p. 545).

Catarrh—Hay Fever.—A sulphurous acid spray applied to the nostrils often relieves the annoying symptoms of both these maladies. Sulphur-fumigation is also said to have cured them quickly (Dewar, Pairman), but this cannot always be depended upon (McGregor, Edin. Med. Journ., Oct., 1869).

Chronic Bronchitis.—The spray is sometimes a useful adjunct in the treatment of this condition; it acts as a stimulating expectorant, thinning the tough viscid phlegm; sulphur-fumigation is also good (Fergus). It will not, however, accomplish the wonders at one time expected from it, and should be commenced cautiously.

Asthma.—In this capricious malady, sulphurous sprays and fumigations have been tried, and apparently with advantage, but more often with marked increase of irritation; as a rule, other remedies relieve more.

Phthisis.—Dr. Dewar has recorded a remarkable case in the person of a groom advanced in phthisis, with emaciation, cough, sweatings, hæmoptysis, etc., and apparently in a hopeless condition, who conducted sulphur-fumigations for cattle (*v.* p. 312), remaining with them in the sheds "with the most wonderful benefit to his own health: within one week the night-sweats had ceased, his cough abated, and expectoration diminished; he gained weight—nearly two stone in four months: is now dependent for his life on one lung only, or nearly so, but with the exception of being somewhat short-winded, looks nearly as strong and as able for ordinary work as before his illness" (Pamphlet, On the Application of Sulphurous Acid Gas, 1866). He reports four other cases of "chronic phthisis" equally benefited; and Mr. Pairman corroborates his observations; they deserve careful consideration, but up to the present there has been little further trial of the method.

It was thought that the sulphurous *spray* would be of great service in the relief of phthisical symptoms, but I have not seen lasting or important results from it, though it facilitates expectoration and lessens laryngeal irritation.

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Fumigation in Infectious Disease, etc.—The burning of sulphur for the prevention or cure of infectious disorder long preceded any modern scientific inquiry. The Chinese esteemed it highly in prehistoric times. Ulysses, according to Homer, employed it to disinfect his palace after slaughtering the suitors, calling it "the remedy of all evils, and cure of all sores" (Odyssey, Book xxii., line 481, etc.). Ovid praises it in the Fasti, and Pliny in his Natural History; but it is within quite recent years, and since the recognition of a "germ theory" in disease, that the systematic use of sulphurous acid, *within*, as well as without, has been placed upon a logical basis or fairly pressed upon the profession as a method of treatment.

When cattle plague was epidemic, Dr. Dewar found the best results from fumigating cattle sheds with sulphurous acid. His own cattle never suffered, and "a large dairy, notorious for thirty years for mortality amongst its cows (from pleuro-pneumonia), and which for eight years of the then tenant's occupancy had never been free from disease for a month, in which sixteen cows had lately died, the last three days before fumigation began; this dairy from that time till the date of writing had been perfectly healthy." He states also that "an epidemic of diphtheria was cut short by it; two cases having occurred in one house within twenty-four hours, and no others after sulphur-fumigations." Mr. Pairman reports similar experience, but it must be said that neither author, however earnest and truthful in reality, writes in such a manner as to convince the profession, and hence, perhaps, they have not yet widely influenced ordinary practice.

The variola epidemic, arrested on the coast of Iceland by Dr. Hjaltelin, seems to me admissible evidence of the value of the gas, though even this arrest has by some been attributed to the quarantine and isolation enforced. Twenty-two cases were brought on shore from the fishing vessels; seven were confluent; only one died (moribund on admission); *in no instance did the disease spread.* A workman employed in the hospital did not catch small-pox, although shortly after he proved susceptible to vaccination; in every case the attack was quickly and favourably modified: results which may fairly be connected with the treatment—constant use of sulphur fumes in the air, and the

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giving of sulphurous solution internally (B. M. J., ii., 1871). (An epidemic of small-pox in the last century—1707—destroyed one-fourth of the population of the same country.)

Dr. A. W. Foote, during the last epidemic of variola in Dublin, endeavoured to carry out a thorough disinfectant treatment in his wards at the Meath Hospital, giving sulpho-carbolates as well as sulphurous acid, applying the latter locally, and burning sulphur three or four times a day; he treated 59 cases, of which 24 were confluent, 6 semi-confluent, and 11 died, and he concluded that the treatment was of value, and that sulphur vapour acted "as a prophylactic," but was irritating to bronchitic subjects. This fact is important, for in confluent small-pox, laryngitis is a frequent and serious complication (Dub. Journ., and Med. Times, April, 1872).

On the other hand, we have to note unsatisfactory results from the use of similar treatment during an epidemic at Trinidad. Dr. Bakewell, though not furnishing many details, states that he treated twenty-five patients with sulphur-fumigations and sulphurous acid, apparently "without any effect" (Med. Times, i., 1872).

The experience of Mr. Fergus as to disinfection after an epidemic of scarlatina is very favourable: upwards of 4,000 blankets and other articles of infected bedding and clothing were exposed thoroughly for four hours to the fumes of burning sulphur, "with complete success" (Practitioner, i., 1877). He is accustomed to depend on a short personal exposure to sulphur fumes after visiting an infectious case, and has never conveyed infection in his own person. He lays stress upon an important point, inattention to which might possibly account for some failure: the vapour should be used at intervals for half to one hour at a time, and at its full strength, rather than by being constantly given off at low tension—the latter method is apt to be ineffective, as well as more likely to give rise to unpleasant sulphur combinations.

The acid bleaches vegetable colours, and corrodes metals, etc., but not so markedly as to cause inconvenience in practice. The pernicious effect on human air-passages, formerly attributed by high authorities to effective sulphur vapour has been quite disproved. Dr. Angus Smith says, "This acid gas is an

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irritant, and causes coughing, which becomes painful and dangerous according to the amount used, and as it is destructive to animal structures it does not seem advisable to use it more than can be avoided" (On Disinfectants): such an opinion has doubtless told against its use, but after the observations of Dewar, Pairman, Fergus, and others, must now be modified.

Cholera. — The burning of sulphur fires round infected villages has been strongly urged (Tuson, Lancet, ii., 1876, p. 313).

Mode of fumigating with Sulphurous Acid Gas.—Dr. Dewar, referring more particularly to the process as applied for cattle plague, recommends as the safest and most convenient apparatus, "a chaffer two-thirds full of red cinders, a crucible inserted therein, and a piece of sulphur stick"—"a piece" the length of a man's thumb will burn for twenty minutes and be sufficient for a shed containing six cattle, and if ventilation be free at the same time, a man can remain without the least risk of detriment —this is repeated three or four times daily. Its efficacy is increased by simultaneous steam-fumigation, and if only "inanimate objects" are to be disinfected, nitre may be added to the sulphur, and thus some sulphuric acid generated (Pamphlet, pp. 7–21).

For phthisical and other patients, the room is simply filled with fumes three times a day. Mr. Pairman places half a teaspoonful of sulphur on paper on a shovel and ignites, repeating this process every twenty minutes till the patient has had one or two hours of fumigation;—the head should not be held too near, nor the fumes made so strong as to excite much coughing. He is in favour of keeping "mild sulphur fumes almost constantly in the sick room," but the occasional and temporary use of a full dose is to be preferred. Dr. A. W. Foote "used" flowers of sulphur dropped on a heated shovel, and carried about the room, and this is quite under control and readily borne by patients unless bronchitis or asthma renders them unusually sensitive. From 1 to 2 dr. will be an average quantity: it is scarcely necessary to make an exact calculation.

If a room is to be thoroughly disinfected in the absence of inmates, the doors, windows, and other apertures should be closed—pasting paper over chinks is sufficient—coloured clothes removed,

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and metal protected by grease or otherwise; then sulphur should be burnt in quantity proportioned to the space, taking Letheby's estimate of 1½ oz. for each hundred cubic feet, or more roughly the proportion of ¾ lb. for a large room (Fergus). If dried and finely powdered, it will burn when lighted, and may be conveniently placed in a small earthen jar standing in water: mixed with $\frac{1}{10}$ part of its weight of powdered charcoal it burns, perhaps, more readily, and will not melt and run over—the charcoal will be unconsumed (Fergus). If this mixture be placed on an iron plate two feet square, it will be safe, though for precaution some would put the plate or vessel over water. After an hour's fuming, a free current of air should be admitted for several hours before occupying the room. Mr. Keates, the chemist, has suggested the burning of bisulphide of carbon as a convenient means of obtaining gaseous sulphurous acid, for much more of this gas is given off than of carbonic acid—especially is this the case if petroleum be mixed with it. In a room of 1,300 cubic feet, 280 gr. bisulphide charged the air so efficiently with SO_2 that one could not remain in it, and a lamp has been contrived to burn a graduated amount (Lancet, ii., 1876, p. 712). It is said too that the offensive smell of bisulphide is got rid of in the purer preparations (Price and Co.), but still it remains highly inflammable, and the method seems more dangerous and more complex than simple sulphur burning.

THERAPEUTICAL ACTION.—*Internal.*—Following up the observations already mentioned as to the effect of sulphites upon dogs, Prof. Polli devised a special method of treating "zymotic" diseases—the "anti-fermentative, or anti-zymotic method," which aimed at prophylaxis by saturating the blood with these remedies. The method made progress in Italy, Spain, and France, not much in Germany, and lately it has lost ground even in the former countries (Nothnagel); still I think that with modifications it has a future before it, and will mark a distinct advance in rational therapeutics. It is applied not only to the specific fevers, cholera, intermittents, and the like, but also to pyæmia and septicæmia generally.

Septicæmia.—Dr. Polli, Dr. De Ricci, and others, have

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recorded cases of pyæmia, phthisis with suppuration, chronic empyema, etc., benefited by sulphites.

Mr. Spencer Wells traced improvement in septicæmic uterine cases to the use of hyposulphites (Med. Times, ii., 1864).

McCall Anderson cured eruptions of furunculi with ½-dr. doses of sulphite of soda (Lancet, i., 1870, p. 897), and Dr. Ricci chronic pemphigus with sulphite of magnesia (Dub. Journ., vol. xxxvi.). Dr. C. B. Radcliffe, when suggesting the use of the same salt in cattle plague, states that he has seen good results from it in fevers (Lancet, i., 1870, p. 897).

Snow Beck used frequent vaginal injections of sulphite of soda in puerperal fever, and gave internally the sulphites of lime or magnesia, and advocated this treatment as better than any other (Lancet, i., 1865, p. 340). Sulphite of soda in 2-dr. doses daily (readily taken in beef-tea) proved valuable in pyæmia in the Liverpool Infirmary (Med. Times, ii., 1868, p. 336), and Dr. Miller, whilst reporting the hyposulphite ineffectual in typhus, found it distinctly of service when given early in septicæmic cases connected with parturition (Edin. Journ., Sept., 1869). This is not a large amount of evidence, and though more might be collected from foreign sources, it would not be enough to place this medication yet on an assured basis, but considering how serious a condition is in question, it well deserves further inquiry. Of course, if blood-poisoning have reached beyond a certain point, recovery is not possible under any treatment, and if the salts employed be not fresh and pure, failure also will result; irritation of stomach and intestinal tract may also hinder their employment, and I think that sulphurous acid is really a better form to employ than its alkaline compounds; but whichever be chosen should be *early* and thoroughly given. There is no objection to combining this medication with the internal use of aconite, and with all recognized remedies to promote elimination.

Variola.—We have already stated that in the hands of Dr. Hjaltelin and Dr. A. W. Foote, the internal use of sulphurous acid solution in small-pox was combined with the external application of the gaseous form, and, so far as could be judged, with good effect. The secondary fever of this malady is due to absorption from the pustular eruption, and

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this ought to be influenced by the early employment of such remedies, and I believe is so influenced. In one exceedingly severe case of confluent small-pox, considered hopeless by a good practitioner, the patient was enabled to take ½-dr. doses of sulphurous acid every hour or two, and within a short time showed signs of improvement, which went on to complete recovery, not in accord with the normal rate of progress in such cases. To variolous pustules maturating, the acid with glycerine is a good application.

Erysipelas.—The relief given by the acid spray in erysipelas by Dr. Hewson and Mr. Pairman has been already noted, but the internal use of the remedy may be well conjoined with the external. In the case of an infant living under unhealthy conditions, and in whom a severe attack of the idiopathic malady affected one arm and leg, the pudenda and head, and when iron had no control over it, the internal use of sulphurous acid seemed the cause of improvement which very quickly followed.

Diphtheria.—Under sulphur it has been stated that the local application of that remedy is not desirable (*v.* p. 39), but sulphurous acid acts very much better, and is, as a rule, well borne, and even liked by the patient.

Dr. Dewar and Mr. Pairman used it rather in fumes and spray or gargle, and conjoined with it iron or chlorate of potash. Dr. Joyce (quoted by Dr. Geo. Johnson, Lancet, i., 1875, p. 82) had the best results from the same practice (with iron). Fergus depends on the acid with ice only, and other observers have had satisfactory results from the salts: thus Dr. Hayden from the hyposulphite (Dub. Quarterly, Aug., 1866). I think the local application of the acid in spray highly desirable.

Enteric Fever.—Whilst recognizing the difficulty of a true judgment about the effect of medicines in this fever on account of some uncertainty in its natural course and duration, and of the usual recoveries independently of any specific treatment, yet I must state my conviction that its course may be favourably influenced by the internal use of sulphurous acid, if commenced *early* enough. I know that many of the highest authorities have taught that the fever-poison having once been received

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must pass through certain changes before elimination, and that the best practice is mainly,—intelligent nursing; but careful observation of many enteric cases has led me to the conclusion that in some instances, under the influence of the administration of sulphurous acid or the sulphites, the attack has been shortened, and in others high temperature and profuse diarrhœa have been relieved, coincidently with improvement in the general symptoms. In some advanced cases, with muttering delirium, sordes, and signs almost of dissolution, a favourable change has occurred shortly after commencing the acid treatment. Of thirty-six consecutive cases thus treated by Dr. Mackey, several illustrated these points, and none died. Special advantage from the acid is not claimed on the score only of the number recovered, for equal results have been recorded from other methods: the number is still too small to justify positive conclusions, but the impression made on my own mind as to the value of the acid is highly favourable.

It is true that sometimes unusual or persistent vomiting interferes with its administration, and the drachm or two-drachm doses recommended cannot always be given: 10 to 30 drops has been an average dose for an adult, when repeated every two to four hours, and when urgent bronchitis contra-indicates this remedy, for a time expectorants and diaphoretics must be substituted. Several years ago, Dr. Hamilton (Liverpool), treating his last eight cases of an epidemic of typhoid with sulphurous acid, "was struck by the mild form assumed, and apparent cutting short of the fever." They were typical cases at the commencement—five children, three adults—and the dose was from 1 to 3 dr.; they were generally better on the second day, and by the fifth day improvement had set in (Lancet, i., 1869, p. 45). Dr. George Wilks, of Ashford, refers to 171 cases of enteric fever treated by him with sulphurous acid, and all ending in recovery, some under very unpromising conditions; thus he instances a poverty-stricken child of four years, with violent vomiting, purging, tympanitis, and delirium, who could not have ordinary care and attention; a woman of seventy-three equally neglected; and a man of fifty-four apparently dying under ordinary treatment of astringents, etc., and yet rapidly recovering after commencement of the acid treatment (B. M. J.,

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ii., 1870). The patients took from 2 to 20 drops with syrup and water every four hours for many days, until they showed ample evidence of the absorption and elimination of sulphur. Dr. Skinner reports twenty cases of enteric fever treated by sulphocarbolate of soda (with one death).

Dysenteric Diarrhœa—Cholera.—Dr. Scoffern writes recommending the sulphite of lime in choleraic diarrhœa (Lancet, ii., 1866, p. 279), but it has not been much used. On the hypothesis of cholera being dependent upon the absorption of organic poison, sulphurous acid ought to prove of some service in its treatment, more so than the sulphites and hyposulphites, which are slower in action and liable to irritate. Professor Graham, indeed, first introduced the solution of sulphurous acid to Sir Wm. Jenner as a possible remedy for cholera, but it has never received full trial. A main difficulty, as regards any remedy in cholera, is to secure its absorption, all vital function being annihilated with such fearful rapidity: hence we can never hope for the same results as in enteric fever, but sulphur fumes should certainly be used as disinfectant and prophylactic.

It has been pointed out that workers in copper, and in powder factories (at Madras especially), have shown special immunity in cholera epidemics, and although Dr. Burq claims specific virtues for copper in this respect (*v.* Cuprum), the presence of sulphurous acid is a more likely explanation (Lancet, ii., 1873).

Ague.—The hypothesis of ague being dependent upon the absorption of minute fungi or spores given off by the soil of malarious districts has been forcibly maintained by H. Schmidt, Salisbury, and others, who have even reported the finding of such microscopic organisms in the blood and secretions of patients, and in the neighbouring marshes (Lancet, ii., 1867, p. 588). Evidence in favour of this theory seems furnished by such instances as that of the ship *Argo*, which took on board for (water supply to) a band of soldiers, water from a malarious district, and almost all who drank of it got intermittent fever, whilst the *sailors* of the same vessel, who had a different water supply, did not suffer (Lancet, loc. cit). Still, the hypothesis is not proved, and clinical evidence as to the value of sulphite treat-

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ment is contradictory—thus, whilst Sanger refers to four cases of intractable ague soon relieved and ultimately cured by scruple doses of hyposulphite of soda (Lancet, i., 1869), McClean criticises the result, and notes that quinine and other remedies had been previously used, and that it is well-known quinine often does not cure, unless a blood depurant, such as potash or soda first be given, and moreover many cases in the Mauritius were treated by the sulphites without effect, and were afterwards cured by quinine (Lancet, i., 1869, p. 511). Several American writers have reported the cure of intermittents by hyposulphites after failure of quinine (Ranking, Abstract, ii., 1868, ii., 1870), but Farelli, from an exhaustive analysis of the recorded evidence, concludes that their good effect is neither so quick nor so constant as that of the latter; they are not prophylactic, and their continued use leads to anæmia: he holds that their action, such as it is, "is reductive, not disinfectant" (Abstract, Lancet, i., 1873, p. 634).

Syphilis.—Several writers, chiefly American, have strongly recommended the internal and external use of the sulphites in the later stages of syphilis (Ranking, ii., 1868). I have had no occasion to prescribe them, but have found the acid locally applied most useful in throat- and other ulcerations. Dr. Purdon has recorded an illustrative case (B. M. J., i., 1868).

Pyrosis—Sarcinous Vomiting.—In these conditions, which are clearly dependent more or less upon fermentations or the presence of low organisms, the influence of sulphurous acid and its compounds ought, *d priori*, to be clearly shown, and so practically we find it, for sulphurous acid in ½-dr. doses is one of the best remedies that can be given. Sir William Jenner was one of the first to point this out (Med. Times, ii., 1853), and Dr. Henry Lawson, one of the first to secure for it the attention of the profession (Practitioner, vol. i). C. Drysdale also early recorded a case rapidly relieved by this treatment after failure of bismuth, prussic acid, etc. (Lancet, ii., 1869). Other physicians have succeeded with the hyposulphites (Med. Times, i., 1853), and even with sulphites, and if Dr. Lawson found no benefit from these, as compared with the acid itself, it was probably because his dose was but small: the hyposulphites,

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however, must deposit sulphur, and as a rule, the acid will be found best.

PREPARATIONS AND DOSE.—*Acidum sulphurosum:* dose, ½ to 1 fl. dr., diluted. For external application the solution may be used in full strength, or diluted with equal parts of glycerine and water, or as a lotion 1 part in 8. *Sodæ sulphis:* dose, 20 to 60 gr., freely diluted: as a lotion (anti-parasitic), 1 part in 8: as an injection, etc., 2 dr. to ½ oz. in 8 oz. of fluid. *Sodæ hypo-sulphis:* dose, 20 to 60 gr. *Calcis sulphis:* dose, 10 to 20 gr. *Magnesiæ sulphis:* dose, 10 to 30 gr. *Potassæ sulphis:* dose, 10 to 30 gr.

ACIDUM TARTARICUM—TARTARIC ACID,

$H_2C_4H_4O_6$ (or H_2T), = 150.

An organic acid very widely diffused: it occurs in fruits partly in the free state, and partly combined with potash or lime.

PREPARATION.—From "cream of tartar"—acid tartrate of potash—which is derived from grape-juice. The process of preparation involves three distinct reactions: (it is a favourite test-question at examinations).

1. The salt having been boiled with sufficient water, prepared chalk is gradually added, and an *insoluble tartrate* of lime is formed and precipitates: but tartaric acid is dibasic, and the other equivalent of basic potash remains in the solution as a *neutral tartrate* (K_2T).

$$2(KHC_4H_4O_6) + CaCO_3 = CaC_4H_4O_6 + K_2C_4H_4O_6 + CO_2 + H_2O$$

2. To precipitate this element of tartaric acid also as tartrate of lime, solution of chloride of calcium is added, giving rise to formation of chloride of potassium, and precipitating the tartrate of lime.

$$K_2C_4H_4O_6 + CaCl_2 = CaC_4H_4O_6 + 2KCl$$

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3. The tartrate of lime, having been washed, is decomposed by sulphuric acid, which precipitates an insoluble sulphate, tartaric acid being left in solution.

$$CaC_4H_4O_6 + H_2SO_4 = H_2C_4H_4O_6 + CaSO_4$$

CHARACTERS AND TESTS.—Tartaric acid occurs in fine white powder, of strongly acid taste, or in large colourless oblique rhombic prisms, which become luminous in the dark on friction. Whilst dry, these are permanent in air, but an aqueous solution becomes mouldy on keeping, with formation of acetic acid (a change which may be prevented by the addition of some rectified spirit). A usual test for tartaric acid in solution (not too dilute) is the formation of a crystalline white precipitate of tartrate of potash on the addition of acetate of potash. Solutions neutralized by an alkali also give with chloride of calcium a white precipitate of tartrate of lime soluble in cold liquor potassæ, but falling again when heated. Tartaric acid may be added to bicarbonate of potash to saturation without any precipitate, but if the bicarbonate be added to the acid, bitartrate is at once formed and precipitates (Squire).

ABSORPTION AND ELIMINATION.—Tartaric acid, in moderate doses, is readily absorbed, but we do not exactly know what changes it undergoes in the system. That it combines with earthy bases is probable, for Wöhler found it in the urine (by which secretion it is eliminated) in the form of tartrate of calcium (Med. Times, ii., 1845). Dragendorff, Buchheim, and Pietrowski found only a small amount in the urine, and conclude that the greater part is oxidized in the body.

PHYSIOLOGICAL ACTION.—*External.*—On the skin, concentrated solutions of tartaric acid produce temporary irritation and burning.

PHYSIOLOGICAL ACTION.—*Internal.*—Digestive System.—Small doses have a cooling taste and quench thirst, but if continued, may irritate the stomach, and large doses cause purging. Very large quantities have toxic effects, though not of so severe a kind as those of oxalic, or even of citric acid (Huse-

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mann). A fatal result is very rare, but Taylor records one in which death followed nine days after taking 1 oz. of tartaric acid in solution: the symptoms and appearances were those of gastro-enteritis. In other cases the mucous membrane of the stomach and the intestines has been found either white (not inflamed) or ecchymosed, with partial softening.

Circulatory System, etc.—Bobrick reported weakening and slowing of the heart-action in frogs, rabbits, and men, after large but non-toxic doses; the vagus nerve was not concerned in this effect (Husemann, Arzneimittellehre, ii., 894). According to Mitscherlich, rabbits die from doses of 3 to 4 dr. with symptoms of adynamia, weakened heart-action, and difficult respiration; the blood is found fluid, in some cases light, in others dark-red.

Bence Jones found tartaric acid increase acidity of urine, and lead to excretion of uric acid in a free state (Lectures, 1867).

SYNERGISTS.—Citric and other vegetable acids.

INCOMPATIBLES.—Alkalies, salts of mercury and lead, and vegetable astringents are incompatible. Lime and magnesia are the best antidotes.

THERAPEUTICAL ACTION.—*External.*—Fœtid Perspiration.—Schottin states that tartaric acid relieves this unpleasant condition, and I can corroborate the observation. For the feet it may be used sprinkled in the stockings, or these may be washed in a strong solution. The powder may also be rubbed into the axillæ, with the caution that if irritation be produced it must be replaced by some soothing powder.

THERAPEUTICAL ACTION.—*Internal.*—This acid, dissolved and sweetened, is sometimes used as a refrigerant drink; and it exerts a slightly sedative effect on the circulatory system. It is sometimes used in place of citric acid, but is not so pleasant to the taste, nor so well borne by the stomach. Of seidlitz powders, the "white paper" contains about 35 to 40 gr. of this acid, which when dissolved and mixed with the same quantity of soda bicarbonate and 120 gr. of tartarated soda (the contents of the "blue paper"), forms a sedative, refrigerant, and slightly aperient draught. Annesley considered tartaric acid of service in excessive secretion of mucus by the stomach or intestine. In

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cases of ammoniacal urine with cystitis from calculi, prostatic disease, etc., I have often found it relieve the symptoms, and render the secretion duly acid and clear: full doses of 20 to 40 gr. well diluted should be given three or four times daily for a short time.

PREPARATION AND DOSE.—*Acidum tartaricum*: dose, 10 to 30 gr. or more dissolved in water, and sweetened. For effervescent draughts, 20 gr. neutralize 26 gr. of potash bicarbonate, 22 gr. of the soda salt.

ADULTERATIONS.—Oxalic acid and lime, sulphuric acid, cream of tartar, and alum are sometimes found in samples of tartaric acid; also lead, which may be derived from the vessels in which it is crystallized.

AMMONIUM, NH_4, = 18.—AMMONIA GAS, NH_3 = 17.

Ammonia exists in the air in minute quantity (probably as carbonate), in sea-water and many mineral waters, and rain-water; in the soil and in animal excretions, especially the urine. It is a usual product of decomposing nitrogenous matter, and is said to occur free in certain plants, as in the leaves of aconite and the root of hellebore. The chloride is found native near volcanoes, and in many coal mines.

Its salts are commonly obtained from "gas-liquor," a product of the distillation of coal in gas-manufacture: when this is neutralized by hydrochloric acid, it yields a chloride, NH_4Cl (sal-ammoniac), and from this salt, when purified, are derived all the other ammonium compounds used in medicine.

CHARACTERS.—Ammonia itself is a colourless gas, which may be liquefied. It has a pungent odour and alkaline reaction; it forms salts with acids, and as these are very analogous in chemical relations to salts of potash and soda, it is believed that they have a metallic base, which is named ammonium, and is the fundamental radical of the series. But while potassium and sodium are *simple*, ammonia is a *compound* body or radical

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mple one, and until its recent isolation as was inferred rather than demonstrated

OR—LIQUOR AMMONIÆ.

ter, the former containing hird stronger than the "spirits of hartshorn," s of horns and hides.

-ammoniac with slaked passed through wash bottles or.

$$= CaCl_2 + 2H_2O + 2NH_3$$

D TESTS.—The stronger solution is colour- ·1 to ·900, of characteristic pungent odour and ion. A piece of moist red litmus paper held in the ne bottle is at once turned blue. *The tests for its purity* —When diluted with four times its volume of water, it gives no colour or precipitate (*a*) with lime water, showing the absence of carbonic acid; or (*b*) with oxalate of ammonia, showing the absence of lime; or (*c*) with sulphide of ammonium, proving its freedom from lead, copper, and other metals; or (*d*) with ammonio-sulphate of copper, showing its freedom from sulphuretted hydrogen. (*e*) When rendered acid by excess of nitric acid, it gives no precipitate with nitrate of silver or chloride of barium, showing its freedom from chlorides, bromides, iodides, cyanides, phosphates, and sulphates.

The properties of liquor ammoniæ are similar, but weaker in degree.

COMPOUNDS OF AMMONIA.

AMMONIÆ CARBONAS—CARBONATE OF AMMONIA, $N_4H_{16}C_2O_6$, = 236.

The real constitution of this complex formula is probably, —two molecules of *acid* carbonate, and one of carbonate of ammonium.

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PREPARATION.—By heating a mixture of chalk (carbonate of lime) and sal-ammoniac (chloride ammon.), when chloride of calcium and a complex carbonate of ammonia are formed; the latter distils over, and is condensed.

CHARACTERS.—When recent it is seen in colourless, translucent, crystalline masses, of strong characteristic odour and acrid taste, markedly alkaline in reaction, volatile, soluble in water, less so in spirit, and effervescent with acids. When exposed to the air it gives off ammonia and carbonic acid, loses its odour, and crumbles into an opaque mass of bicarbonate of ammonium. In consequence of ready decomposition, the aqueous solution of the ordinary salt will contain both neutral and acid carbonates. The neutral salt has not been isolated in the solid state.

AMMONII CHLORIDUM—CHLORIDE AMMONIUM—SAL-AMMONIAC, NH_4Cl, = 53·5.

PREPARATION. — Generally from gas-liquor, by adding hydrochloric acid to neutralization, evaporating the liquid, and purifying the crystals by sublimation.

CHARACTERS AND TESTS.—Occurs in pieces of the hemispherical cakes in which it is sublimed, of translucent fibrous appearance and pungent saline taste—inodorous. Its ordinary form is hard to powder. It is soluble in one part of boiling water and three of cold, its solution being attended by reduction of temperature; also soluble in rectified spirit. Heated with potash, soda, or lime, it evolves ammonia.

AMMONII BROMIDUM (*v.* Bromine, p. 126).

LIQUOR AMMONIÆ ACETATIS—SOLUTION OF ACETATE OF AMMONIA.

Acetate of ammonia, $NH_4C_2H_3O_2$, = 77, dissolved in water, commonly called spirit of Mindererus.

PREPARATION.—By gradual neutralization of carbonate of ammonia with acetic acid.

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CHARACTERS AND TESTS.—When pure and fresh this is a limpid, colourless liquid, without odour and with strong saline taste; but unless carefully kept it soon spoils. With caustic alkalies it evolves ammonia, and with sulphuric acid, acetic vapours.

AMMONIÆ CITRATIS LIQUOR—SOLUTION OF CITRATE OF AMMONIA.

Citrate of ammonia, $3NH_4C_6H_5O_7$, = 243, dissolved in water.

PREPARATION.—By neutralizing a solution of citric acid with strong solution of ammonia. It is a colourless liquid of saline taste.

AMMONIÆ PHOSPHAS—PHOSPHATE OF AMMONIA,

$(NH_4)_2HPO_4$, = 132.

PREPARATION.—By neutralizing phosphoric acid with ammonia, the latter being in excess.

CHARACTERS AND TESTS.—The crystals, which are transparent when recent, become opaque on exposure, and part with ammonia and water. Soluble in water, insoluble in spirit, gives a characteristic yellow precipitate with nitrate of silver.

AMMONIÆ BENZOAS—BENZOATE OF AMMONIA,

$NH_4C_7H_5O_2$.

PREPARATION.—By dissolving benzoic acid in water, with solution of ammonia, and crystallizing.

CHARACTERS AND TESTS.—Occurs in colourless laminar crystals, which are soluble in water and alcohol: they are sublimed by heat. Hydrochloric acid precipitates benzoic acid from the solution, and caustic potash heated with it causes evolution of ammonia. Per-salts of iron give a yellow precipitate.

Ammonii Sulphidum (*Appendix II.*), $(NH_4)_2S$, = 68.—By passing sulphuretted hydrogen into liq. ammoniæ to saturation, then adding more liq. ammoniæ.

$$NH_3 + H_2S = NH_4HS \text{ and}$$
$$NH_4HS + NH_3 = (NH_4)_2S$$

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A colourless liquid, becoming yellow when kept, of disagreeable taste and fœtid odour. It is incompatible with almost all metallic and acid solutions.

Ammoniæ Nitras—Nitrate of Ammonia, NH_4NO_3, = 80. (Placed in the appendix only for the preparation of nitrous oxide gas.)

ABSORPTION AND ELIMINATION.—Ammonia and its carbonate are not wholly absorbed as such—a part becomes changed into chloride in the stomach (Rabuteau). Most of the free ammonia combines with carbonic acid in the organism (Bellini, B. M. J., i., 1874). Salts of ammonia with *organic* acids (citrate, etc.) are decomposed in the capillaries, when the acids are oxidized and ammonia is set free. Compounds of ammonia with *mineral* acids form alkaline salts at the expense of carbonates in the blood (Bellini).

Though Lange did not find ammonia in the air expired by animals taking it (Archiv f. Exper. Path., Bd. ii.), other observers have often done so, and Bellini concluded that caustic ammonia and the carbonate, when taken in small doses, were entirely and very quickly *eliminated by the lungs;* of large doses, some passed also by other channels. Whatever salt was taken, carbonate was eliminated by the lungs.

There is sufficient evidence that the carbonate, when taken in moderate or even large doses, is not excreted as such by the kidneys. Rabuteau took 60 gr. daily for five days without finding any in the urine, which continued acid, whereas a mere trace of ammonia added *directly* to the urine suffices to give an alkaline reaction. Dr. Bence Jones had previously pointed out this continued acidity of urine under ammonia, and suggested that the drug becomes so far oxidized in the system as to give rise to nitrous or nitric acid, which appears in that secretion (Philos. Trans., 1851, and Med. Times, ii., 1854). Only after very large doses (160 gr. daily) *some* carbonate of ammonia is eliminated in the urine, which then becomes alkaline, and deposits ammonio-magnesian phosphate.

Ammonium *chloride* does not readily decompose in the system; it is excreted by the urine and partly by the saliva (Rabuteau); a small quantity passes out by the skin.

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Frerichs taught that in uræmia an unusual amount of ammonia carbonate (arising from decomposition of urea) circulated in the blood and was excreted by the lungs, and although some doubt has been thrown upon this by Dr. George Johnson and others (Med. Times, i., 1858), it certainly occurs in some cases (cf. p. 331). Richardson has pointed out that during an *actual attack* of uræmic convulsion, the amount of ammonia excreted is less than at other times on account of the retention of urea in the system (Lancet, ii., 1860). Gull found ammonia, when the albumen in the urine was not large in amount (Med. Times, i., 1861, p. 616). Uræmic coma is, however, connected with the circulation of urea, etc., rather than of ammonia (Med Times, i., 1862).

PHYSIOLOGICAL ACTION.—*External.*—The vapour of carbonate of ammonia (smelling salts) is stimulant and slightly irritant, that of the strong ammonia is intensely irritant to the whole of the air-passages and conjunctivæ, and has even caused fatal bronchitis. Liquid ammonia is also a strong local irritant; diluted with oil it is "rubefacient," but applied in strength, and evaporation prevented, it vesicates, and if injected under the skin causes severe sloughing. Oertel reported that the direct application of liquor ammoniæ to the air-passages caused a membranous effusion similar to that of croup; but very careful observations by Meyer on the same point verified only a local catarrhal inflammation and hæmorrhage (B. M. J., ii., 1874). Ammoniacal urine commonly irritates the bladder.

Ammonia has marked antiseptic powers: 1 dr. of liq. ammon. fort. on lint under a bell-jar preserves morbid specimens, and the same quantity with water preserves them better than spirit.

PHYSIOLOGICAL ACTION. — *Internal.* — **Circulatory System.**—Medicinal doses of ammonia and its compounds quicken the heart's action and capillary circulation, but only for a comparatively short time: such stimulation is not always marked in healthy persons—it is more evident in the weak and in invalids: there is increased sense of warmth, the face becomes flushed, the eyes more brilliant, and the mental condition stimulated.

Ten drops of the liquor, diluted with 1 or 2 oz. of warm

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water and *injected into a vein*, excite the heart so powerfully as to rouse a patient from a state of collapse (Tibbitts, Med. Times, ii., 1872). Larger quantities—30 drops—given in the same manner, after a momentary arrest, stimulate intensely, and may induce convulsion: still larger quantities cause momentary fall of arterial pressure, then sudden and enormous rise, with corresponding increase of pulse-rate: this result occurs equally after division of the cord, hence it is not due to stimulation of the vaso-motor centre, but of the accelerator nerves of the heart (Lange).

On the other hand, according to Rabuteau, 40 gr. of *carbonate*, dissolved and *injected into a vein*, weaken the cardiac contractions and render them irregular, whilst 60 gr. cause a sudden arrest of the circulation, the heart-muscle being paralysed.

The corpuscles are altered by toxic doses; they cease to contain the normal quantity of oxygen, and do not absorb it even when shaken up with the gas (Feltz and Ritter).

The continued use of ammonia salts causes similar toxic effects; the pulse becomes very feeble, and the corpuscles pale and wasted, as after typhoid fever; this is but the recognized effect of all alkalies. These results are reported by Cazenave (Bull. de Thérap., t. xxxi.), yet Pereira has given 15 gr. thrice daily for two months without apparent injury, and often a scruple thrice daily for two or three weeks.

Ammonia or its carbonate added to blood outside the body renders it or keeps it fluid, and when given internally, exerts an influence in the same direction; Dr. Richardson even thinks they have sometimes caused disintegration of clot already formed in the vessels (*v.* p. 335). Coagulation of blood is not, however, due to escape of ammonia, as thought probable at one time, nor will ammonia always or wholly prevent it. A difference in *time* of coagulation was the only difference observed by Rabuteau in experiments on dogs, for whilst coagulation of their blood usually occurs in two minutes after withdrawal, it occurred only in ten minutes when 60 gr. of ammonia carbonate had been injected: the clot, however, was firm and resistant.

Chloride of ammonium delays coagulation of blood, and when added to it with access of air renders or keeps it red, as do other chlorides.

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Nervous System.—Ammonia salts, in medicinal doses, stimulate the general nervous system, probably by quickening circulation, but the special effect of large doses is exerted on the motor tract of the spinal cord, which is stimulated much in the same manner as by strychnia. Convulsions are produced, especially by strong intravenous injection, and as these occur equally when communication with the brain is severed, they are not cerebral in origin (Lange): neither do they start in the peripheral nerves, for they take place if the blood be cut off from these nerves by ligature (Funke): we conclude them, therefore, to be of spinal origin (Pflüger's Archiv, Bd. ix.), and section of the nerve-trunk of a limb stops their occurrence. Prostration follows the convulsive seizure, and a partial paralysis of the hinder limbs of animals (Rabuteau, and Béhier, Comptes Rendues, Soc. Biol., 1873). Spiegelberg made certain experiments in order to test the opinion of Frerichs that the convulsions of albuminuria were due to the circulation of ammonia carbonate, and when he had injected as much as 6 gr. of that salt into the veins of a dog, general convulsions occurred with clonic spasm and trismus, the pupil was dilated, general sensibility was reduced, and coma set in; after an hour and a half, free salivation and urination took place, and the animal recovered, remaining stupid for some time: larger doses caused vomiting, afterwards, tetanus and coma; the vessels were found full of dark fluid blood (Lancet, ii., 1870). It is probable that ammonia is a direct and intense *stimulant of respiratory centres* in the medulla.

The full effects of *chloride of ammonium* are not often exemplified, but in the case of a lunatic who swallowed a large (unknown) quantity, there were vomiting, giddiness, shivering, depression, delirium, convulsion, and later collapse so complete as to simulate death: recovery was effected with galvanic and other powerful stimuli, and then tetanic spasms came on (C. Browne, Lancet, i., 1868). Temperature is raised under the physiological action of the chloride; lowered under the other salts.

Digestive System.—Ammonia and its carbonate have a direct antacid effect on the gastric secretions, and moderate doses induce a sense of warmth and stimulation at the epigastrium.

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More than 5 gr. is likely to irritate; 10 gr. will commonly nauseate, and 20 gr. will produce vomiting. Diarrhœa is sometimes observed from continued medicinal doses (Cazenave). Liquid ammonia, when swallowed, acts as an irritant poison, and in fatal cases has caused inflammation and erosion of the upper part of the alimentary tract: occasionally it has acted upon the larynx, and induced rapidly fatal œdema glottidis. Death has been caused by 2 dr. of the strong solution; in other cases by 1 oz. (B. M. J., i., 1878), and ½ pint (B. M. J., ii., 1878).

Secretion and Excretion.—Medicinal doses of ammonia, under favourable conditions of warmth, etc., increase most of the secretions, such as those of the skin, the kidneys, and the bronchial mucous membranes. The liq. ammoniæ acetatis has a special action on the skin and kidneys, the carbonate on the lungs, the chloride on the liver and kidneys (Stewart, Rutherford). The pulmonary secretions and the bile are also rendered more fluid—ammonium chloride especially stimulates the latter secretion. The alkaline salts of ammonia are not "remote antacids," *i.e.*, they do not render the urine alkaline.

Influence on Nutrition—Urea.—Although ammonia is seldom taken long enough in medical practice to directly affect nutrition, there is evidence that its continued use will produce debilitating effects like other alkalies—as indeed might be expected from its influence on the blood. Cazenave has reported pallor, anorexia, debility, and emaciation; and Huxham, a case in which hectic, hæmorrhage, and general marasmus followed upon the habitual eating of ammonia carbonate (Essay on Fevers). Prout noted a great increase in the amount of urea excreted under *citrate of ammonia*, taken for dyspepsia, and the same thing has been recorded in cases of debility with irritable bladder, and pale urine of low sp. gr. (Med. Times, ii., 1863). Rabuteau, however, as the result of experiments on himself in health with 75 gr. of citrate daily, found that urea was slightly diminished, and also sulphates, but that phosphates were much increased in amount. Richardson maintains that ammonia suspends oxidation, and checks formation of all downward products of albumen, and retards nutrition (Med. Times, i., 1862, ii., 1866). There are not many observations on this point, but according to Lange, ammonia

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carbonate may itself furnish, by decomposition, an additional quantity of urea.

Under the *chloride*, however, urea is distinctly increased, and oxidation of tissue rendered more active.

The iodide and bromide of ammonium exert the absorbent and sedative effects of alkaline bromides generally; if anything, they are more active and less depressing than the corresponding salts of soda and potash.

SYNERGISTS.—Diffusible stimulants, heat, and, according to Gubler, opium and iodine. Both Gull and Paget have pointed out that ammonia aids the action of iodide of potassium, and it has been asserted that 5 gr. of the latter, with 3 gr. of ammon. carb., is equivalent to 8 gr. of the iodide alone (B. M. J., i., 1874). Volatile ammonia assists also the action of antispasmodics, such as valerian, castor, etc. Other alkalies and bases assist its antacid power.

ANTAGONISTS — INCOMPATIBLES. — Cold, emollient drinks, quinine, tannin, interfere with the action of ammonia, and are "dynamic antidotes" (Gubler).

Incompatibles are acids and fixed alkalies, salts of iron (except the tartarated iron), calomel, lead salts, etc. Freely diluted, ammonia and its carbonate may be used as antidotes to mineral acids. Christison, Pereira, and others, consider them also antidotal to prussic acid: they certainly have dynamic effects, opposite in character to those of the acid, though they do not chemically neutralize it: they antagonize also the toxic effects of alcohol, and in some degree those of animal poisons.

THERAPEUTICAL ACTION.— *External.*— **Neuralgia — Rheumatism, etc.**—The strong liquor ammoniæ has been used as a counter-irritant, or a rapid vesicant, in cases of muscular, neuralgic, and rheumatic pain, and to relieve deeper-seated inflammation, for instance, of the tonsil and fauces, by derivation to the skin. For such purposes the ammonia liniment may be rubbed in, or if vesication be necessary, it may be secured in the course of five minutes by the strong liquor applied on lint. Dr. Waring recommends, as a simple method,

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to fill the lid of a wooden pill-box with circular pieces of lint to above the rim, saturate with the liquid, and invert over the part. M. Gondret introduced a vesicating ointment made with ammonia and one-fourth part lard and olive oil, and it is commonly used in France. M. Ducros advised painting the liquor over the palate and gums for relief of tic.

Falling off of the Hair.—The stimulating properties of ammonia are highly useful in promoting growth of hair when it has been thinned by debility or illness. Half an ounce of the strong liquor, with almond oil, rosemary spirit, and honey-water to about 6 oz. is a good proportion (E. Wilson).

Amenorrhœa—Pruritus.—In cases of chlorotic amenorrhœa, a stimulating vaginal injection of about 1 dr. of liq. ammoniæ to a pint of warm milk has been found useful by Dr. Ashwell, and I have frequently ordered it with advantage, the breasts being stimulated at the same time by friction with weak ammonia liniment. Dr. Dewees has recorded the cure of an obstinate case of pruritus pudendi by a similar injection.

Local Inflammations.—Lotions containing ammonium chloride are very useful in inflammatory swellings of muscles, joints, lymphatic and other glands, and sometimes in the hydroceles of children—2 dr. may be used to 4 or 6 oz. of spirit and water.

In *orchitis* and in *milk engorgements* with heat and tension of the breasts, the same application is cooling and absorbent. Guéneau de Mussy recommends for the latter cases an ointment containing 5 parts of the chloride mixed with 1 of camphor and 30 of lard, to be used frequently. It is said that threatening abscess may be aborted by the continued application of compresses wet with spirit of rosemary containing about 1 dr. of the salt to the pint, and if an abscess has formed of indolent character, such as bubo often is, it may be stimulated to heal by the injection of sal-ammoniac solution after withdrawal of some pus (Ranking, i., 1871).

Acne.—In chronic cases of acne simplex with comedones, a lotion containing the chloride with alum and sulphuret of potash is sometimes an effective resource.

Stings—Snake-Bite.—Dilute liquor ammoniæ relieves the

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pain that follows the stings of venomous insects, wasps, etc.; it should be freely rubbed into the part, and given internally if there be tendency to collapse.

Professor Halford (Melbourne) has strongly advocated *intravenous injection* of ammonia in snake-bite, using 15 to 30 min. of the liquor, diluted with 3 or 4 parts of water, both as antidotal to the poison, and as a general stimulant. Many cases have recovered under this treatment, but there is yet much doubt as to how far it may be depended upon: in some of them it is probable that the bites were not of fatal character, and when experiments were repeated with more accuracy, ammonia, even injected by Prof. Halford, did not avert a fatal result (Med. Times, ii., 1876). It has also been found powerless against the bite of Indian snakes, which are more poisonous than those of Australia (Fayrer, Short, Brunton, Ewart): in some cases death followed even more quickly than usual after the injection (Report of Commission).

The intravenous injection of liq. ammoniæ is a subject of much importance, and one that deserves more general attention than has yet been given to it: it is not free from risk and danger, especially if the large dose of 30 min. be used, but in suitable quantity it has powerfully stimulated the heart, and revived cases apparently in articulo mortis.

Shock and Collapse from Injury, etc.—Cases of fracture and laceration accompanied with collapse and treated by ammonia-injections have been recorded by Mr. Tibbitts. In one man, 40 drops with 2 oz. of warm water were passed into one of the veins of the arm, and after temporary arrest of breathing, a violent convulsion occurred; but on subsidence of this, general stimulation was evident, and he rallied for several hours. In a second case, 30 drops were injected, with a somewhat similar result; in the third patient, when only 10 drops were given, pulse and respiration were at once restored, vomiting occurred, and recovery followed (Med. Times, ii., 1872).

Recovery, though only temporary in character, followed a similar injection given during collapse in severe *scarlet fever* (B. M. J., i., 1877), and in the same condition, occurring during *puerperal fever*, Tyler Smith injected 30 min. with 3 parts of water, and ultimate recovery followed; but two cases thus

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treated by Mr. Spencer Wells proved unsuccessful (B. M. J., ii., 1869).

Narcosis.—Neild injected 30 drops of ammonia on four separate occasions in a patient fatally narcotized by *chloroform*; temporary recovery occurred each time (Med. Times, i., 1871). In a case of *opium*-poisoning, when 40 gr. had been taken, and death was imminent, revival, though only for a time, also followed directly on ammonia-injection (B. M. J., ii., 1872). Mr. Richards has specially drawn attention to the value of ammonia-injections in *alcoholic coma*, and has shown that some of Dr. Halford's patients who had much brandy (one got a bottle and a half in three hours) were really more comatose from the alcohol than from the bite, and hence their recovery. He remarks on the importance of a slow injection, and recommends 10-min. doses (Lancet, i., 1880, p. 115).

Exhaustion.—In a case where extreme exhaustion was consequent on prolonged suppuration, 15 min. were injected into a vein, and again eight hours afterwards with permanent good result (B. M. J., i., 1877); some of the caustic entered the cellular tissue, and caused local sloughing, and in other cases, where injection has been made purposely into this tissue, serious ulceration and abscess have followed (Med. Times and Lancet, i., 1870).

THERAPEUTICAL ACTION. — *Internal.* — **Exhaustion—Alcoholism, etc.**—One of the most frequent uses of ammonia, and one which it commonly serves very well given by the mouth in the ordinary manner, is to quicken the general circulation and to revive failing heart-action in cases of exhaustion and threatened syncope from almost any cause: being volatile, it diffuses and acts rapidly. The vapour of the carbonate, as disengaged from "smelling salts," is sometimes usefully given by inhalation in the same class of cases, and the vapour of liquor ammoniæ has been utilized in partial asphyxia, and in the semi-coma of drunkenness. In several extreme cases of alcoholism, wherein relapses were frequent, I have known the aromatic spirit of ammonia in drachm-doses every hour or two "steady" the patient very markedly: it has acted better than, *e.g.*, vinegar, which seemed to increase liver congestion and give only temporary relief to symptoms. The depres-

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sion and dyspepsia which commonly follow excessive use of alcohol are also well treated by ammonia compounds, especially if combined with valerian: in the prostration of delirium tremens, the same remedies are very useful.

Thrombosis—Embolism.—Rapid separation of fibrine in the heart-cavities seems to occur previous to death in many acute exhausting diseases, such as pneumonia, croup, peritonitis, etc., and after prolonged or difficult parturition. Dr. B. W. Richardson states that advantage may be derived in such apparently hopeless condition from the use of liquor ammoniæ ♏x. every hour, alternately with iodide of potassium (Ranking, ii., 1872). Dr. Shepherd Fletcher (Manchester) has reported a well-marked case of embolism occurring in a puerperal woman and recovering under 5-gr. doses of ammonia carbonate given every hour (B. M. J., i., 1864), and Dr. Philipson has recorded another illustration of the same character (B. M. J., 1865). More recently, Dr. Richardson has written to point out distinctive signs of the separation of fibrinous coagula in the large thoracic vessels—*e.g.*, dyspnœa with open air-passages, fulness of the neck-veins, feeble pulse with tumultuous heart-action, and weakened first sound: for such conditions he strongly advises the persistent administration of ammonia, not so much as a stimulant, but as a solvent of blood-clot, and preventive of putrefaction (Lancet, i., 1875). I cannot, however, yet adopt so sanguine a view of this medication (*v.* p. 328).

Pyrexia. — In acute pyrexial and inflammatory conditions, solutions of acetate and citrate of ammonia relieve many of the symptoms by promoting secretion from the skin and kidneys.

Typhus and Typhoid Fever.—In adynamic stages of these fevers, ammonia has often been used, but not always with advantage; thus Stillé reports its failure, though largely given during an epidemic of typhus at Philadelphia. There is reason to believe that the amount of ammonia circulating in the blood is unduly increased in these maladies, and this would be a reason against using it: certainly its administration is very distasteful to the patients.

Scarlatina.—On the other hand, there is much clinical evidence of the value of ammonia in this fever. De Witt,

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Peart (1802), Wilkinson, and Strahl have written specially in its praise, and many illustrations of its value have been given by Hillier, Camden, Graham, Sisson, Langdon Down, and others (Lancet, 1860, 1864, 1870, Med. Times, 1858, 1862, 1873, and Lond. Hosp. Reports, vol. i.). From 3 to 6 gr. of carbonate, freely diluted, are to be given every one or two hours, until improvement occurs: it determines to the skin, and perhaps thus hastens elimination of the poison. I have found it especially useful in cases accompanied by malignant sore throat. Dr. Down refers to 192 cases occurring in one epidemic at Earlswood asylum; 78 had severe angina, and 49 were malignant cases: all received 5 gr. of the carbonate every four hours, and were otherwise treated alike: alcoholic stimulants were used in moderation. Ten only died, and of these seven were tuberculous, and considering the low resisting power of imbeciles this result is good. He considered the remedy diminished febrile excitement and calmed the nervous system: it was taken readily without pain to the throat.

Chest-Diseases.—In acute stages of pneumonia, bronchitis, or pleurisy, the acetate or citrate of ammonia is often serviceable. In asthenic cases, the later chronic conditions of bronchitis, and in senile catarrh, the carbonate and liquor are good stimulant expectorants, being eliminated in part by the pulmonary membrane, they modify its condition and thin the secretion. Ammonium chloride is also valuable in such conditions, and in asthenic lung-congestions: it may at first increase pyrexia, but generally facilitates the expectoration, "softens the cough," and improves appetite. Dr. Patton has written to commend the carbonate in acute pneumonia, and the chloride in later stages (Practitioner, vol. vi.)

In the bronchitis of measles, and of rachitis, ammonia is commonly and advantageously used,—Sir W. Jenner, indeed, speaks of it as *the* remedy in the lung-affections of the latter malady, which are generally asthenic and tend to collapse (Med. Times, i., 1860). On the other hand, Dr. Eustace Smith maintains that if too early given to children with bronchitis it may determine even a fatal issue (Med. Times, i., 1873).

Croup.—In the later stages, when the membrane is more or less loosened, and perhaps capillary bronchitis is present, car-

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bonate of ammonia may prove a useful stimulant expectorant or emetic.

Pertussis.—I have seen relief given to the cough in later stages by inhalation of ammonia vapour, and Mr. Grantham has devised a simple method of effecting this by adding 1 oz. of the liquor to 1 gallon of boiling water in a bucket or bath, and then putting in a red-hot brick (B. M. J., ii., 1871). The atmosphere of gas-works has often relieved chronic cases, a good effect which has been traced to the volatile sulphide of ammonium.

Bronchial Catarrh—Hoarseness.—The chloride of ammonium in vapour deserves trial in obstinate cases of this kind, and Dr. H. Beigel introduced an arrangement of three bottles, one containing liquor ammonia, another hydrochloric acid, and a third "wash-bottle" with water, through which air impregnated with the vapour was drawn for inhalation (Lancet, ii., 1867): it has not come into general use. Liebermann has suggested another form of apparatus for inhaling it (Bull. de Thérap., 1873).

The bromide is of service in capillary bronchitis (Bartholow), in pertussis, and other spasmodic coughs.

The chloride in lozenge and vapour has also been advised for hoarseness and granular sore throat, but the stimulus at first sometimes aggravates the symptoms.

Nerve-Diseases—Migraine.—The acetate of ammonia in 1 to 2-dr. doses will often relieve sick-headache. The chloride, in 10 to 20-gr. doses, is indicated in bilious and nervous forms occurring in the young, and in delicate over-worked women,—"it stimulates the sensory nerves, and regulates the vaso-motors" (Anstie, Practitioner, vol. i.).

In headache connected with menorrhagia it is said to be more useful than in that connected with irregular or suppressed menstruation (Barallier, Bull. de Thérap., 1859).

Neuralgia.—In true neuralgia, the chloride is often of great value, as Dr. Clifford Allbutt states after observation of fifty cases (Med.-Chir. Rev., Jan., 1872): it is, however, very nauseous to some patients.

In tic-douloureux, or facial neuralgia, especially if there be a marked rheumatic element and the lower jaw be affected, ½-dr. doses of chloride should be given at short intervals, for four

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doses: relief will probably have then set in if this remedy is going to benefit (Watson, Lectures, vol. i.). In cases accompanied with heat and swelling, Brenchley recorded marked relief to pain and lowering of temperature under this treatment (Ranking, ii., 1858).

In *hemicrania* from nerve-prostration it is often curative (Med. Times, i., 1875), and in *sciatica* I have found either carbonate or chloride valuable, more or less permanently when the pain is worst when the patient is in the standing or sitting posture. In *intercostal* neuralgia, in anæmic or suckling women, in *hepatalgia*, and in *ovarian* neuralgia, Dr. Anstie also reported much benefit from the chloride; and of the latter malady Dr. W. Curran has reported six severe cases marked by acute pain, pyrexia, vomiting, etc., occurring mostly at a period, and accompanied with fulness over the region of the ovary, all much relieved by the chloride in 15-gr. doses, which were given, however, with 5 min. of aconite (Ranking, ii., 1868).

Dysmenorrhœa.—The acetate of ammonia will often relieve the pain of congestive dysmenorrhœa. I have frequently prescribed it with success, especially if there be a sub-inflammatory or turgescent state of mucous membrane, or when suppression has occurred from cold, shock, or fatigue (B. M. J., i., 1878, etc.).

Uterine Disorder, etc.—The chloride has often produced good results in amenorrhœa (Cholmeley, Practitioner, vol. ii.), and Dr. Anstie advised it in cases marked by general feebleness rather than by anæmia. Dr. Atlee states that the salt has in his practice caused the diminution of fibroid tumours (B. M. J., i., 1868). This observation may be compared with that of Dr. Rae, who asserts that the same salt is valuable in goître and glandular enlargements (Ranking, ii., 1858), but there is not much evidence on these points.

Myalgia.—For this variety of pain, Dr. Anstie affirms "nothing in the whole list of remedies comes near the chloride in efficiency," and H. Jones speaks of its power in muscular rheumatism "as remarkable and positive" (Lancet, ii., 1859).

Hysteria.—Ammonia relieves several of the symptoms of this disorder, such as the lassitude and tendency to fainting, and the flatulent distension of stomach. The aromatic spirit is

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a good preparation in common use. The liquor with asafœtida or valerian is still more effective, but nauseous; it has some power in staying convulsive attacks of hysterical character.

Dyspepsia—Acidity, etc.—In cases where flatulence with acidity are marked symptoms, ammonia will relieve by its alkalinity and by stimulating the stomach to contract and expel flatus; it is usefully combined with other remedies—the carbonate or aromatic spirit with soda or bitters. The chloride with hydrochloric acid relieves in some cases when the tongue is furred and the biliary secretion deficient (B. M. J., i., 1875). For gastric and intestinal catarrh, also, it is commonly given in Germany—not so in England.

Hepatic Disorders.—In various forms of hepatic disorder accompanied with congestion, ammonium chloride is a valuable remedy, perhaps not yet sufficiently known in this country. Dr. Murchison recommended it in "functional liver-disorder" accompanied with lithæmia, and Dr. Anstie in suppression of biliary secretion consequent on nerve-shock. It is much used abroad in catarrh of the bile-ducts, and in the jaundice dependent on this condition; also in hepatic dropsy; but perhaps its best effects are seen in passive hepatic congestion when there is deficient intestinal secretion with loaded urine, constipation, coated tongue, and general "bilious" condition. As already stated, the chloride stimulates a due secretion of bile and increases the excretion of urea. Dr. Stewart, of the Indian service, has especially drawn attention to the value of this remedy in *hepatitis*, and even *hepatic abscess*, and has found it act better in acute than in chronic stages of these maladies. If the skin be dry, he orders first the acetate of ammonia and afterwards 20 gr. of chloride every four or six hours: a feeling of warmth and exhilaration is produced, hepatic pain is quickly and markedly relieved, perspiration and urine are freely secreted, and sleep commonly follows (Lancet, 1870; B. M. J., ii., 1878).

Hæmorrhage.—In hæmorrhage of different kinds, usually passive in character, the chloride is praised by Copland, who gave it with hydrochloric acid. It is not much used, but Warburton Begbie has seen good results from doses of 20 gr. in hæmaturia: in the illustrative case recorded by him, there was no definite cause for the malady (Lancet, ii., 1875).

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Urinary Disorder.—In acute *albuminuria*, the liquor ammoniæ acetatis is often useful, as first noticed by Addison (Lancet, ii., 1855), and in *diabetes*, Barlow, Golding-Bird, and Bouchardat, specially valued the carbonate as being a stimulant and a nitrogenous substance (Guy's Reports, vol. v., etc.). Basham recommended the phosphate to be given with the carbonate and lemon-juice (B. M. J., i., 1869). Prout also thought the citrate serviceable, but rather as a diaphoretic than as possessing specific powers. The sulphide has been recommended to lessen morbid appetite in diabetes, but it does not diminish the excretion of sugar (Garrod), and ammoniacal salts have not retained their reputation in this serious malady.

In **Vesical Catarrh and Prostatitis**, the chloride has proved useful, and in a case of irritable bladder, with pale urine of low sp. gr., and deficient in urea, much relief was apparently given by the citrate; the excretion of urea was at once increased under its use (Med. Times, ii., 1863). The benzoate of ammonia is valuable in chronic catarrhal cystitis, with phosphatic deposit; also in scarlatinal dropsy (Lancet, ii., 1861, Garrod, Med. Times, 1864).

PREPARATIONS AND DOSE.—*Liquor ammoniæ fortior:* dose, 3 to 10 min. well diluted, but seldom used internally. *Liquor ammoniæ:* dose, 10 to 30 min. well diluted. *Spiritus ammoniæ fœtidus* (with asafœtida): dose, 30 to 60 min. *Ammoniæ carbonas:* dose, 3 to 10 gr. or more as a stimulant; 30 gr. as an emetic. *Spiritus ammoniæ aromaticus* (sal-volatile): dose, 15 to 60 min. *Ammonii chloridum* (sal-ammoniac): dose, 5 to 20 gr. or more. *Ammonii bromidum:* dose, 2 to 20 gr. *Ammonii iodidum* (not officinal): dose, 1 gr. and upwards. *Liquor ammoniæ acetatis* (spirit of Mindererus): dose, 2 to 6 dr. diluted freely. *Liquor ammoniæ citratis:* dose, 2 to 6 dr. *Ammoniæ benzoas:* dose, 10 to 20 gr. *Ammoniæ sulphidum* (in solution): dose, 3 min. and upwards (seldom used: dangerous if incautiously given). *Ammoniæ nitras:* used only for making nitrous oxide. *Ammoniæ phosphas:* dose, 5 to 20 gr. freely diluted. *Linimentum ammoniæ* (with olive oil), for external use. *Compound camphor liniment* also contains ammonia solution.

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METALLIC PREPARATIONS.

ALUMINIUM, Al, = 27·5.

THIS metal has not been found native, but *alumina*, its oxide, Al_2O_3 (known also as argillaceous earth), is widely diffused as a silicate in clay, slate, granite, etc., and occurs nearly pure in the sapphire and ruby. The metal itself is of steel-grey colour and is not readily oxidized: sp. gr. 2·67.

Alumen, the officinal alum, $NH_4Al(SO_4)_2 12H_2O$, is a double sulphate of alumina and ammonia with a large amount of water of crystallization: it occurs native sometimes in mineral waters, and in efflorescence on stone. (There are many similar "alums," or double sulphates of an alkaline base, and a metal: thus there is a potash-alum—formerly officinal, but more expensive than ammonia-alum—a soda-alum, etc. The same name is applied even when no alumina is present, as to the double sulphate of iron and ammonia—iron-alum—and to similar compounds of manganese and chromium.)

PREPARATION.—The officinal alum is prepared by oxidation of aluminous schist, sulphates of alumina and iron being formed, then dissolved in water, and treated by sulphate of ammonia: on concentrating the solution, alum crystallizes out.

CHARACTERS AND TESTS.—Alum crystallizes in octahedral, sometimes in cubic forms, but is generally met with in irregular lumps, translucent and colourless when fresh, efflorescent and covered with small crystals after exposure. It has an acid reaction and a strongly astringent, subacid taste; is insoluble in alcohol, soluble in eighteen parts of cold, and half its weight of boiling water. Heated, it dissolves in its water of crystallization, and when this has been driven off, alum remains as a dry, white, spongy mass (*alumen exsiccatum* vel *ustum*—dried, or

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burnt alum). This has very astringent, somewhat caustic properties; it readily absorbs moisture, but is sparingly soluble: heated beyond 400° F. it is decomposed, and alumina, the oxide, Al_2O_3, remains. This oxide is insoluble in water, and when alum solutions are decomposed, separates as precipitate; hence the use of alum for clearing turbid water, for when it is added, the alkaline and earthy salts present in the water combine with the sulphuric acid of the alum, and the alumina which precipitates, carries with it most of the impurities present: it has also special disinfecting powers.

The *acetate* of alumina (argilla acetica), the *chloride* (aluminium chloratum), and the *single sulphate* (argilla sulphurica), though not officinal, are in occasional use; they are all soluble salts, of characteristic styptic taste. The sulphate has been found native, though not quite pure; it is more acid than the ordinary double sulphate, so that it blunts steel instruments and corrodes linen.

1. The bisulphide of ammonium (NH_4HS), when added to solution of the salts of aluminium hydrate, gives a white gelatinous precipitate of ammonium hydrate. 2. The caustic alkalies and their carbonates give a white precipitate with aluminous solutions, soluble in excess of the former. 3. Solutions of the aluminous salts should not give a blue colour on the addition of ferrocyanide and ferricyanide of potassium, showing fredom from iron. 4. Alum, when heated with caustic soda or potash, evolves ammonia.

ABSORPTION AND ELIMINATION.—Taken into the mouth alum exerts the local action presently to be described, and its first sweetish taste is followed by a peculiar feeling of constriction, and abundant flow of saliva: after reaching the stomach, combined, more or less, with albumen, some of it becomes absorbed though slowly. Orfila detected it in the urine and viscera of dogs after large doses (Annales d'Hygiène pub., i., 235—9, v.), and Krauss found the urine become very acid under its use. The greater part of the alum taken combines to form insoluble compounds with the bile and other organic products, and is eliminated with the fæces. It is remarkable, that although alumina is so common a constituent of vegetable food, it is not

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found in the human organism, showing how completely it passes out.

PHYSIOLOGICAL ACTION.—*External.*—Alum acts as a typical simple astringent, contracting the arterioles and muscular fibres of the part touched by it, and rendering the surface pale and dry. It combines with albuminous secretions forming whitish flakes, or membranous films, insoluble in water, but soluble in acetic and hydrochloric acids (Mitscherlich). If there be not enough fluid present to saturate the alum, it affects the deeper tissues in a somewhat caustic manner: this is especially the case with the dried salt. Strong or long-continued applications excite irritation with some degree of inflammation, and under such circumstances, discharge from an affected part—*e.g.*, the conjunctiva, or the vaginal mucous membrane—may be increased rather than diminished.

The *acetate of alumina* and *chlor-aluminium* have marked disinfectant powers, preserving organic tissue, and hindering putrefaction. Burow (1857) found that the acetate, mixed with fresh blood, formed a brown syrupy mass, in which the shape of the corpuscles was not retained, but which remained, without decomposing, for many months. Albumen, treated with the same salt, continued clear, and did not coagulate much on boiling: 0·5 per cent. prevented putrefaction of urine and of meat, and 2 per cent. sterilized bacteria.

The *chloride of aluminium*, chlor-alum, was introduced (mainly by Mr. John Gamgee) as a disinfectant free from poisonous or corrosive properties; it not only prevents decomposition, but removes its products by absorbing gas, etc.: it serves best, perhaps, for the disinfection of closets, drains, etc: in the post-mortem room it is useful, but locally applied renders the muscular tissue pale (Lund, Med. Times, 1873).

PHYSIOLOGICAL ACTION.—*Internal.*—Digestive System. —Small doses (3 gr.) taken several times daily, in water, cause dryness of mouth and throat, thirst, and diminished secretion in the alimentary canal, the stools being rendered harder and less coloured than normal (Wibmer). Doses of 10 gr. disorder the digestion by lessening the gastric secretion, and from 15 to

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60 gr. cause cramping pain and nausea (Barthez): 2 to 3 dr. induce vomiting without much straining, and larger continued doses may cause colic and diarrhœa with considerable *increase* of secretion from the intestinal mucous membrane.

In *rabbits*, which do not vomit, 2 dr. proved fatal, with evidence of inflammation and erosion of the stomach (Mitscherlich). To *dogs*, Orfila gave 1 to 2 oz. without other marked effect than vomiting, though if a ligature were passed round the œsophagus, 1 oz. would cause death in a few hours (Devergie). In these cases the gastric membrane was found to be either white and wrinkled, almost tanned, or was distinctly inflamed in patches.

Devergie concluded from his experiments that the human was more sensitive than the canine stomach, and certainly large doses of 1 to 2 oz. cause in man much burning pain, frothing at mouth, vomiting, purging, and depression: the symptoms of gastro-enteritis may develop themselves, but usually the emetic action gets rid of the drug before serious injury is produced. The results vary somewhat with the condition of the stomach at the time, for at a trial in Paris it was proved that a lady, the subject of chronic dyspepsia, took about 20 gr. of burnt alum (by mistake for gum arabic), and suffered from enteritis in consequence. Orfila gave evidence that such a result was due to exceptional causes, and that 4 to 6 dr. were often given without inconvenience. More recently, death has been reported in a man aged fifty-seven from taking 13 dr. of burnt alum: he suffered from a sensation of burning and constriction, general malaise and anguish, hurried respiration, and nausea with sanguineous vomiting: intelligence remained good (Union Méd., No. 64, 1873).

Alum was at one time largely, and even now is to some extent used in the adulteration of bread, for it gives a whiter colour to the flour. Injurious effects, such as dyspepsia and constipation, have been attributed to it, and though Christison failed to notice bad results from any amount that came under his notice, I have myself often traced indigestion to alum in the bread: it would certainly follow the use of any large quantity. (It may be noted that ordinary natural wheat flour would give about 4 gr. of silicate of alumina to the 4-lb.

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loaf, and the determination of the amount of added alum has been a frequent puzzle to analysts—Med. Times, ii., 1875.)

THEORY OF ACTION.—We are not yet able to explain exactly the manner in which alum produces its effects, though doubtless its affinity for water, and its power of coagulating albumen, are important factors. M. Mialhe supposed the astringent action to depend upon a chemical decomposition, viz., the precipitation of alumina by the alkaline elements of secretions, or of blood; and he further supposed that the *secondary* effect of increased discharge—which we have mentioned—was due to an absorption of the recently-formed alumina rendering the blood more fluid (*v.* Stille, vol. i.). This chemical explanation is not, however, satisfactory, for taking only the latter point, astringent effects persist, as a rule, after the absorption of any ordinary doses, and it is only under the continuance of large doses (1 to 2 oz.), irritative by their mere mechanical effects, that discharge is increased; such increase, therefore, is better explained as a consequence of direct local irritation than of fluidity of blood. It is not uncommon for astringents—nitrate of silver, for example—in dilute solution to lessen discharge, and when more concentrated to increase it.

SYNERGISTS.—Tannin, sulphuric acid, and astringents generally, favour the action of alum, and are often combined with it; but as tannin decomposes alum, it seems probable that if given in the same mixture or compound, the substances may really prove less astringent than when given separately.

ANTAGONISTS—INCOMPATIBLES.—If an over-dose of alum be taken, mucilaginous and albuminous liquids, such as milk with white of egg, or gum arabic, or fluid glue, should be freely given. Magnesia should be added, according to v. Hasselt, or carbonate of ammonia in small quantities (Taylor). Alkalies and their carbonates, and acetate of lead, are chemically incompatible with alum.

THERAPEUTICAL ACTION.—*External.*—Alum is one of the oldest known remedies, and was often prescribed by Hippocrates and Celsus: its properties, as already described, render it un-

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suitable for the acute stages of any active inflammation, but most useful in many chronic catarrhal conditions, and relaxed states of mucous membrane.

Skin-Diseases, etc.—In some forms of discharging skin-disease, such as chronic eczema, an alum lotion of moderate strength (1 dr. to 6 or 8 oz.) will act favourably as an astringent; it is also useful if sponged over the surface in profuse and exhausting perspirations. On indolent sores and fungous granulations the powder may be sprinkled, opium being added, if desirable, to lessen the pain that may be caused: this combination, combined with catechu, has also been praised in hospital gangrene. The "lapis divinus," which is prepared with equal parts of alum, blue-stone, and nitre, fused together, is a stimulant application to ulcerated and discharging surfaces, much used on the Continent, and compounds of alumina have lately proved very serviceable as disinfectant and alterative dressings.

The acetate of alumina, and the double sulphate of alumina and zinc, have been specially recommended in lotion for fœtid perspiration and ulceration. Thorey prescribed the chloride for diphtheritic and gangrenous sores, though others report it unduly irritating.

For *antiseptic surgery* Professor Maas and Dr. Pinner have recently reported favourably, after extensive trial, of alumina acetate (Berlin. Klin. Woch., 12-13, 1880, and Med. Times, i., 1880). Since the salt is not stable as a solid, they make a solution of 1,000 parts of "colloidal alumina" in 800 parts of dilute acetic acid (thus giving a proportion of about 15 per cent.) for preparing an antiseptic gauze, which is cheaper than, and quite as efficient as, the carbolic. For the spray, a strength of 2½ per cent. is chosen; this is strong enough to lessen hæmorrhage, and does not anæsthetize the hands: for washing the skin and the instruments, carbolic solutions are still retained.

Stomatitis, etc.—When small ulcerations occur in the buccal mucous membrane, and when there is gingivitis or sponginess and inflammation of the gums, dried alum, applied in the form of powder, or a lotion containing it with myrrh and spirits of wine, is very useful. Salivation is also restrained by its moderate use, and injurious effects on the gums during a mercurial course may be prevented by keeping a piece of alum in the mouth for

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a few minutes occasionally. At Aix-la-Chapelle, patients are ordered to use alum gargles and washes frequently during the mercurial treatment.

Toothache dependent on caries may often be cured by the local use of a paste made with alum, ether, and mucilage, which should be applied until the sensitive nerve is destroyed (Legaulon).

In Catarrhal Angina and "relaxed throat," especially for relaxed uvula, the gargle of Rivière (1 dr. of alum to 6 oz. of water) is still a frequent prescription. It is said, however, to be injurious to the teeth, and plain water should be used after it.

In Hoarseness, a gargle containing 2 dr. of alum in 6 oz. of barley water has been found useful for professional singers (Bennati): the remedy is still better applied in the form of spray (10 gr. to 1 oz.)

Tonsillitis.—In early stages even of acute tonsillitis, insufflation of very finely-powdered alum, or warm, weak alum gargles will often assist in cutting short the attack, but if this be fully developed before treatment is commenced, alum would be more likely to irritate than to relieve: its use is better reserved for chronic congested conditions, with or without spots of ulceration, when the fine powder should be gently blown over the affected part through a quill or suitable tube.

In Purulent Ophthalmia, as occurring especially in children, an alum lotion containing 4 to 6 gr. to the ounce is very useful when properly applied: it should be used very frequently, every half-hour or hour, in a gentle stream, so as to thoroughly cleanse the lids, and in addition drops of a weak solution of nitrate of silver may be required once daily: this method is the most relied upon at the London Ophthalmic Hospital (Med. Times, ii., 1873).

In Gonorrhœal Ophthalmia, and in the severe ophthalmiæ of Egypt and India, similar frequent use of alum lotions is also serviceable. My colleague, Mr. Macnamara, has seen cases cured in the latter country by applying round the orbit a mixture of burnt alum with lemon-juice.

In Catarrhal Conjunctivitis and Chemosis, a convenient and useful application is the alum curd, made with boiling

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milk, or the alum "poultice," prepared by rubbing a little of the powder with white of egg till a coagulum is formed; this is placed between two layers of thin cambric and applied over the closed lids.

Otorrhœa—Ozæna.—In sub-acute or chronic stages of otorrhœa, an alum-injection of the strength already mentioned—4 to 6 gr. to the ounce—is cheap, and often effective: its use should be preceded by a douche of plain water, otherwise the alum will be prevented by coagulated secretion from directly reaching the affected membrane. The remedy should not be continued too long, or it may excite irritation

In chronic ozæna (offensive nasal discharges), a douche of double or treble strength may be used. Homolle has recommended the *single sulphate* as a better remedy for this disorder, and others have preferred the chloride (chloralum) or acetate.

Nasal Polypi have sometimes been cured, or greatly relieved by the insufflation of finely-powdered alum, or strong alum solution.

Leucorrhœa—Gonorrhœa.—Injections of alum alone, or combined with zinc or oak-bark, are often used with advantage, especially in leucorrhœal discharges: a strength of about 5 gr. to the ounce is usually sufficient, and plain water should be first injected to cleanse the surface. In the early acute stages, as already mentioned, alum is not suitable, and at any time, too strong a solution applied to the vagina may cause irritation and cramping pain.

Prolapsus.—Leucorrhœa is commonly accompanied by a relaxed condition of vaginal mucous membrane, which is also amenable to alum. A good method of using it is to place a sponge, soaked in its solution, well within the vagina for several hours; this will often relieve the slighter forms of prolapsus uteri. Rectal prolapsus should be bathed with alum water before being returned, and afterwards an injection of the same should be practised.

The severe **Pruritus** and burning about the vulva and the anus, often associated with leucorrhœa and prolapsus, may be equally relieved by strong alum solutions.

In the **Vulvitis** of children, Dr. Ringer regards alum as one of the best remedies, recommending a solution of 1 dr.

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to the pint of water, to be applied constantly, and injected occasionally.

Excoriations of Cervix Uteri.—The local application of alum was, at one time, much praised in this condition (Delmas, Brit. and For. Rev., July, 1841).

Chronic Catarrhal Cystitis.—This obstinate disorder may be often relieved by the use of a weak alum-injection—10 gr. in the pint: the bladder should be first washed out with warm water, so as to avoid the clotting of discharge.

I have known vesical pain and frequency of micturition quickly relieved by such injections, which have been followed also, in several instances, by marked diminution of the thick, gelatinous, ropy mucus commonly secreted in this malady: the alkaline reaction and acrid ammoniacal odour of urine have been removed at the same time. The last-named conditions may be dependent sometimes on the introduction of low organisms by a soiled catheter (Traube, Niemeyer), but even in such cases, alum-injections are equally useful by their antiseptic properties. Blockley and Parkington specially recommended the single sulphate for vesical and vaginal catarrh.

Hæmorrhage—Epistaxis, etc.—Alum is serviceable applied externally in cases of bleeding from superficial vessels, as from the surface of wounds or mucous membranes, *e.g.*, of the nose or of the vagina, from hæmorrhoids, from leech-bites, or after tooth-extraction: in such cases it may be used in substance, a pointed plug or the fine powder being firmly pressed on the part, or a compress steeped in a strong warm solution may be allowed to cool upon it. Such applications condense the tissues and contract the vessels, but it should be borne in mind that if too strong or too prolonged, they may give rise, especially in scrofulous subjects, to unhealthy ulceration. The alum powder is sometimes combined with zinc sulphate, or diluted with starch or sugar, and the solution may be made with decoction of logwood. Combined with benzoin and alcohol, it forms a celebrated styptic and antiseptic, the "Aqua Pagliari" (benzoin, 100 gr., alcohol, ½ oz.; dissolve and add water, ½ pint; alum, 1 oz.; boil till clear, then filter). The solution of Mentel is similar, but made with the single sulphate.

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THERAPEUTICAL ACTION.—*Internal.*—The internal use of alum is combined with its external application in many varieties of hæmorrhages, though it is not depended upon so much now as formerly: it is best suited for cases of "passive hæmorrhage," with relaxed condition of mucous membrane, and when no acute inflammation is present.

In **Hæmoptysis**, tubercular or otherwise, when moderate but persistent, it is a good adjuvant to other remedies, *e.g.*, sulphuric acid. Skoda commonly gave 10-gr. doses with Dover's powder. A spray containing the same quantity in 1 oz. of water may be used with advantage at the same time.

In **Bleeding from the Stomach** or bowels—dependent as these symptoms often are upon cirrhosis, and when passive and atonic in character—alum may be a suitable remedy; its astringent effect in such cases is, in part, at least, direct and local.

In **Menorrhagia** Cullen specially commended alum, and it is still used more frequently perhaps in this flux than in any other. In the form of "alum whey," which is prepared by boiling 2 dr. of the powder with 1 pint of milk, straining off the curd, and adding sugar, it is a not unpleasant medicine, of which a wineglassful, three or four times daily, will generally control the discharge—according to my own observation.

Hæmaturia.—In bleeding from the kidneys, alum whey is also useful, but "iron alum" (double sulphate of iron and ammonia) is a still more active remedy, which has, in my experience, acted better than many others. In cases where blood comes from the mucous membrane of the bladder or urethra, and when pain, straining, and undue frequency of micturition are present, I have known speedy benefit follow the use of alum injections (20 gr. to the pint) into the bladder.

Albuminuria.—The drain of albumen in Bright's disease is practically equivalent to a loss by hæmorrhage, and it has been sometimes restrained by the use of alum: thus, Oppolzer and Heller have reported benefit from it in chronic cases (quoted by Dr. W. Roberts), but after repeated trials I have not been able to verify their good results.

Diabetes.—In diabetes insipidus, or "polyuria," when there

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is an excessive flow of limpid but non-saccharine urine, alum deserves further trial, though the malady is anomalous and often is uncontrolled by any remedies. In true diabetes a partial and temporary benefit has been derived by some patients for whom I have prescribed it.

Gastric Catarrh.—In cases with vomiting of glairy mucus, alum is a cheap and efficient remedy. Sir J. Murray, one of the principal advocates for its use, pointed out that it acted better when given in substance than in solution: thus a pill with gentian extract is a good form, or an electuary with honey.

Diarrhœa.—I have found alum very useful in infantile diarrhœa when arising from errors in diet, and attended with vomiting, acidity, and green stools: from 1 to 5 gr. may be given with syrup. Diarrhœa dependent upon relaxed conditions of mucous membrane is also cured by alum. Fouquier and others have praised it in enteric fever (Bull. de Thérap., ix., p. 301), but it is not easily taken, and it is liable to irritate, so that other remedies are usually to be preferred. Alumina, or argilla pura, is placed in the Austrian Pharmacopœia as an antacid remedy for diarrhœa, especially in children, and is used like bismuth salts. Barthez recommends the single sulphate as preferable.

Dysentery—Moseley, in his work on tropical diseases, considers alum to be one of the best medicines in acute and chronic dysentery, and Dr. Waring has often seen it useful in asthenic cases; it was commonly given with opium. I think that a good mode of administering it in chronic cases is by injection, from 10 gr. to 2 dr. in a pint of liquid being used at a time (Hannon, Bull. de l'Acad., xxxii.); this will also relieve the troublesome tenesmus, and the sense of itching and excoriation about the anus. One drachm to the pint is a proportion I have commonly used twice daily with good success: a strength of ½ oz. to the pint has also been used, but caused some burning pain; improvement, however, soon began, and cure resulted after about fourteen days of treatment (Med. Record, 1879).

Constipation.—Besides the astringent power exerted by 5 to 10-gr. doses of alum, we must notice the irritant effect of larger quantities, by which probably they become useful in constipa-

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tion. Alum is seldom to be preferred to other remedies for this disorder, though it may act favourably in atonic cases, when the muscular coat of the bowel is deficient in power, and when mucous secretion is scanty. Mr. Aldridge has published reports illustrating the good effect of 20 to 40 gr. daily in producing copious and solid evacuations; he also associated it with sulphate of magnesia (Braithwaite, vol. xii.). Such treatment, however, is rarely worth trial, and my own experience with it is not favourable; it either increased constipation or caused dysenteric symptoms.

Lead Colic.—In this common and painful malady, which is always accompanied by obstinate constipation, there is much evidence of the virtue of alum, dating from the last century. Dr. Copland praises it, and M. Brachet of Lyons, writing from a large experience, awards to it the first place amongst remedies: for eight years he states that the treatment he employed consisted of emetics and purgatives, then he gave a trial to antiphlogistics, and then to opiates: lastly, influenced by the success of Gendrin, he commenced to give 1½ to 2 dr. of alum daily in mucilaginous liquid, and either with or without laudanum; on the third day usually the bowels acted, and if not, an aperient was given and the patient was nearly or quite cured, and this in upwards of 150 cases. The successful cases of M. Gendrin were fifty-eight in number, and he experienced no failures with the alum treatment.

In considering how it may operate, it is curious to notice the different views that have prevailed as to the pathology of the malady. M. Baumés, Mialhe, and others, consider it a general poisoning of the system; Combalusier limits the poisoning to the primæ viæ; Cullen, Vogel, and others, make the colic a nervous affection, Willis refers it to the brain, Serre to the spinal cord; Orfila and Grisolle consider it a lesion of the abdominal nerves, or the great sympathetic, whilst Bracher and Andral trace it to lesion both of cerebro-spinal and ganglionic nerve-centres.

The intestines have been most generally regarded as the seat of disease, either in all their structure or in their mucous or their muscular coat. Méral especially argues that the latter is in a state of paralysis, a conclusion which has been widely accepted,

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and alum has been supposed to act partly as a stimulant to the paralysed muscle, and partly as a direct chemical antidote to the lead which it converts into an insoluble sulphate. In support of this view it may be mentioned that other sulphates, as of magnesia, soda, zinc, and free sulphuric acid also act favourably; but it scarcely explains the quick relief that is sometimes given, and one cannot say that its mode of action is quite clear. It would seem to have a specific power of relieving pain, because it has proved useful in other varieties of gastralgia and colic (Dr. Griffin, on Spinal Irritation, etc.).

I have myself only witnessed the good effects of the drug in two cases of lead-poisoning which presented all the usual symptoms: it relieved the pain and terminated the constipation; from 10 to 20 gr. may be given every two hours, properly diluted, and this quantity may be increased to 1 dr. or more, if necessary. Sulphuric acid and syrup of lemon form a suitable vehicle for it: in some cases it is well combined with a little opium.

On the other hand, several good authorities report less favourably of the remedy: Tanquerel and Grisolle found it almost inert, and Brown records increase of pain and of constipation from its use. Husemann, who may be taken as representing the German school, speaks of it as "obsolete," but with us it certainly is not so; Dr. Bartholow, for instance, in his recent treatise, describes it as "most effective" in the relief of the pain, the vomiting, etc.

Emetic Action—Croup.—Besides its astringent and stimulating power, alum, in doses of about 1 dr., is a very useful emetic, because it is prompt in action, and does not depress the system: hence it has been recommended in croup both to dislodge the false membrane and hinder its re-formation; it may be repeated every quarter of an hour for several doses. Narcotic poisoning has also been treated by it.

Whooping-Cough.—In the chronic stages of this complaint, where secretion is profuse and spasm severe, and there is not much complicating bronchitis or pyrexia, I have seen alum exert a very beneficial influence: 4 to 10 gr. in water or syrup should be given three or four times daily. Dr. Golding Bird introduced and highly commended this treatment, conjoining the alum with conium and dill-water. Dr. Meigs states that alum has given

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him, in sixty-eight cases, better results than any other remedy (Diseases of Children). Its good effect may be traced, probably, to a local astringent action on the fauces; hence it is best administered in some thick vehicle, and swallowed slowly.

Asthma—Bronchitis.—It is said that a paroxysm of asthma may sometimes be prevented by placing about 10 gr. of alum on the tongue (Ringer). In bronchitis, 5 to 10 gr., given every four hours, serve to facilitate expectoration, and at the same time its amount is restrained and dyspnœa relieved. Moseley praised this use of alum many years ago, and advised it both for acute and chronic forms with viscid ropy expectoration; but it is in these latter cases only that I should consider it suitable.

PREPARATIONS AND DOSE.—*Alumen*: dose as an *astringent*, 10 to 20 gr.; as a *purgative*, 30 to 60 gr. or upwards; as an *emetic*, 1 dr. to 1 oz. In lead colic, 20 to 120 gr. have been given in the twenty-four hours. *Alumen exsiccatum*: the dose should be somewhat less, and practically this preparation should be kept for external use only. The *solid drug* seems to be more effectual than the liquid form; it may be given in pill or in confection with sugar, honey, or molasses: cream of tartar may be added, if necessary, to obviate constipation, and cinnamon or other aromatics to prevent flatulence. The "*Pills of Helvetius*," formerly celebrated, contained 3 gr. mixed with "dragon's blood;" a more modern formula is with gentian, rhubarb, etc.

In *solution* it may be given with sweetened aromatic water or mucilage, or sulphuric acid and syrup of lemons may be added; or an "alum whey" may be made by stirring 2 dr. of the powder with a pint of boiling milk, straining, and adding sugar.

For a *collyrium*, a strength of 5 gr. to the ounce of rose water is suitable: for a *gargle* from 8 to 20 gr. in the ounce: for a *lotion* or *injection* it may be well combined with zinc sulphate, as in the liq. aluminis co. (L.P.), which was ordered with 1 oz. of each salt to 3 pints hot water. *Ointment*: 12 to 24 gr. to the ounce of simple ointment. *Liniment*: with white of egg and camphorated spirit (for bedsore).

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ANTIMONIUM—ANTIMONY—STIBIUM, Sb, = 122.

This substance, which is now classed amongst metalloids, occurs native, but in small quantities. It is usually found in alloy with various metals, chiefly iron, lead, and arsenic, and from these its purest commercial samples are seldom quite free. Traces of it occur also in some chabybeate waters, and its oxide constitutes the "white antimony ore" (valentinite): its most common ore is the sulphide, from which crude antimony is obtained by fusion with iron, or by roasting and reduction with charcoal.

When pure, it is silvery white in colour with a tinge of blue, laminated in structure, brittle, and crystalline; it is heavy (sp. gr. 6·7) and permanent in the air at ordinary temperature. In its chemical relations it is allied to nitrogen and phosphorus, and still more closely to arsenic.

COMPOUNDS OF ANTIMONY.

ANTIMONIUM NIGRUM—BLACK ANTIMONY, Sb_2S_3, = 340.

PREPARATION.—From the native ore stibnite, by fusing and then reducing to a fine powder.

CHARACTERS AND TESTS. — A crystalline steel-grey metallic-looking powder, which dissolves in boiling hydrochloric acid, with evolution of sulphuretted hydrogen.

ANTIMONIUM SULPHURATUM—SULPHURATED ANTIMONY, Sb_2S_3, Sb_2O_3.

(Golden or precipitated sulphuret, an oxy-sulphide).

PREPARATION.—By dissolving the black sulphide in caustic soda with the aid of heat, and adding sulphuric acid; several complex reactions occur, and sulphurated antimony is precipitated.

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CHARACTERS AND TESTS.—An orange-red powder, inodorous, almost tasteless, insoluble in water, soluble in hydrochloric acid, also in solutions of caustic alkali, and of acid tartrate of potash: exposed to light and air it partially decomposes, with separation of sulphur.

There are several other reddish or brown oxy-sulphides of antimony, and all have been termed "kermes mineral," from some resemblance in colour to the insect kermes (cochineal).

ANTIMONII CHLORIDI LIQUOR—SOLUTION OF CHLORIDE OF ANTIMONY, $SbCl_3$, = 228·5.

PREPARATION.—By dissolving black antimony in hydrochloric acid.

CHARACTERS AND TESTS.—A heavy, yellowish-red liquid, which, when poured into water, gives a dense white precipitate of oxy-chloride (SbOCl).

The pure chloride, which may be obtained by distillation, is volatile, but concretes, on cooling, into a soft, white solid, "*butter of antimony*;" and this term is sometimes given to the officinal solution.

ANTIMONII OXIDUM—OXIDE OF ANTIMONY, Sb_2O_3, = 292.

PREPARATION.—By decomposing the oxy-chloride with sodic carbonate.

CHARACTERS AND TESTS.—A greyish-white powder, inodorous, tasteless, and insoluble in water, soluble in hydrochloric acid: moderately heated, it turns yellow, at a red heat it burns, or sublimes in crystals.

ANTIMONIUM TARTARATUM—TARTARATED ANTIMONY—TARTRATE OF ANTIMONY AND POTASH—TARTAR EMETIC, $KSbC_4H_4O_7H_2O$, = 343.

PREPARATION.—By mixing the oxide of antimony with acid tartrate of potash and water for twenty-four hours, afterwards boiling in water, and crystallizing out.

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CHARACTERS AND TESTS.—Occurs in rhombic, octahedral, colourless crystals, transparent when fresh, but effloresing on exposure to air; also, and more frequently, in the form of powder, which should be perfectly white, a yellowish tinge indicating the presence of iron. It is odourless, but has a sweetish, sub-acid taste, which quickly becomes metallic and nauseous, but may not be much noticed if the powder be largely diluted. The crystals are best obtained for microscopic examination by evaporating on a slide a drop of the hot solution: characteristic triangular facets are seen, and some modifications of the cube, and they are larger than *arsenical* crystals: branched crystalline forms also occur, as in many other saline solutions. The crystals of tartar emetic are isomorphous with those of the *sulphate of potash*, but the latter do not effloresce. Tartar emetic is soluble in two parts of boiling, and in fourteen parts of cold water; less soluble in proof spirit, or in wine, and insoluble in absolute alcohol. Acids, except tartaric acid, occasion a white precipitate, as also do alkalies, alkaline earths, and their carbonates, but excess of these agents will re-dissolve the precipitates.

The dried salt, like other tartrates, decrepitates and chars on the application of heat, and its solution in water readily becomes mouldy from the development of a fungus (a little added spirit will prevent this).

Infusion of galls, catechu, cinchona, strong tea, or tannin in any form, precipitate a tannate of antimony, which is so insoluble as to be practically inert. The following tests are applicable to any soluble antimonial salt:—(1) If it be boiled in water with one-sixth part of pure hydrochloric acid and a strip of metallic copper, antimony will be deposited on the metal, violet-red in colour if the quantity be small, but iron-grey, or black, if in large amount. (2) A solution acidulated with the same acid ($\frac{1}{16}$th) gives, in the cold, a black deposit on pure tin. (3) Sulphide of ammonium, or sulphuretted hydrogen, produces, in acid solutions, an orange-coloured deposit soluble in hydrochloric acid (boiling), and if this latter solution be poured into water, a white deposit of oxide occurs. (4) Evolution of nascent hydrogen (as from zinc and sulphuric acid) in the presence of antimony, leads to the formation of antimoniuretted hydrogen: this burns with a

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blue flame, and produces on porcelain a black stain which is insoluble in bleaching powder.

ABSORPTION AND ELIMINATION.—Soluble compounds of antimony, such as tartar emetic, are readily absorbed, especially by mucous membranes, and they circulate in the blood, either unchanged or as albuminates. The infant at the breast may be affected by them through the mother, and they may be detected in the different secretions during life, and in the viscera, especially the liver, kidneys, and intestines, after death.

The degree of absorption naturally varies with the preparation used, the dose, and the state of the stomach. Metallic antimony in powder, the oxide, and the sulphuret are absorbed to some extent, but much less freely than the potassio-tartrate, which is itself more completely absorbed, and acts more powerfully, if acid wines or fruits are taken at the same time (Trousseau). Large doses are usually vomited soon, and before much absorption has occurred; but if taken with, or shortly after food, vomiting is delayed, and a poisonous amount is more readily taken up into the circulation. This does not conflict with the statement made by Trousseau, that if a patient be living *well*, irritant effects, such as vomiting and purging, are more likely to occur from medicinal doses of antimony, whilst *spare diet* favours the production of constitutional effects, such as sedation and increased secretion, without so much gastric irritation. This fact has been explained by the presence of more chlorides in a full diet (as compared with a spare one), leading to the formation of more of the irritant chloride of antimony (Mialhe); but Bellini found that no such decomposition occurred with artificial gastric juice at the temperature of the body, and the hypothesis of Mialhe has not been accepted.

If the mucous membrane of the alimentary tract be inflamed, the irritant effects of antimony are proportionately severe.

Absorption may occur through the skin, though not readily whilst the epidermis is intact. After frictions with antimonial ointment vomiting has occurred, and the drug has been found in the urine (Coze, Bull. de Thérap., 1869).

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Antimony is *eliminated* by the kidneys, the skin, by the mucous membrane of the bronchi, and (mainly) by that of the intestines, and by the intestinal glands. Orfila recorded its special determination to the lungs, and Millon to the liver (Annales d'Hygiène, vol. xxxvi.). An important fact is that elimination occurs by the intestinal tract, even when the drug has been given by the veins, the rectum, or any other channel (Hermann, Richardson, Brinton, and others, Lancet, i., 1856). The amount passed out by the kidneys, and probably by the other glands, varies at different times in the same individual, for Mayerhofer, whilst continuing to take the drug, found it only occasionally present in the urine (Heller's Archiv, 1846).

The time of its remaining in the system has been variously estimated. According to Taylor, it passes wholly from the stomach within a short time, and may then be found in the liver, the kidneys, and spleen, and in smaller quantities in the blood. After a few weeks, all traces have disappeared from these tissues, but some may be found in the fat and the bones; generally, elimination is complete in from twenty to twenty-five days, but according to Millon and Lavran, the drug may be found in the liver and intestines four months after administration (loc. cit.).

PHYSIOLOGICAL ACTION.—*External.*—The watery solution of tartar emetic applied to the skin acts as a slight irritant, producing redness, but the ointment when rubbed in acts more powerfully, causing inflammation and pustulation; caries of subjacent bone has even been traced to it. The pustules produced by antimony are very painful; they are irregular in size and shape, but being often umbilicated, resemble those of variola: they mature about the fifth day, forming scabs; sometimes they slough and leave scars. Individuals vary much in susceptibility to the ointment, and during fever, or severe visceral inflammation, pustulation is not easily induced.

It has been stated that alkalies mixed with antimonial salves prevent their pustulating effect, and also, but incorrectly, that freshly-blistered surfaces do not pustulate because of the

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alkalinity of the serum: on the other hand, acids increase the effect (M. Coze, loc. cit.).

If concentrated solutions be taken by the mouth, they are liable to cause inflammation and even aphthous ulceration about the gums, fauces, and œsophagus, so that an "antimony sore throat" has been described, and its accompanying salivation and dysphagia may be very severe. Conditions much resembling those of diphtheria have also occurred (Med. Times, i., 1846), but are not often met with under the present more cautious use of the drug.

The prolonged contact of antimony determines in the intestinal mucous membrane local phlegmasiæ analogous to those already described as occurring in the skin; Trousseau verified this by post-mortem examinations.

PHYSIOLOGICAL ACTION.—*Internal.*—Circulatory System.—Under the influence of antimony, the blood is altered in its chemical characters (Richardson), but in a manner not yet well understood; it may certainly become impoverished from destruction of red, and increase of white corpuscles (Schmidt), just as under the action of arsenic (Koschlakoff): in cases of poisoning by the drug, it has been found more fluid and less coagulable than normal, the amount of fibrine being diminished.

A prominent symptom of the full action of antimony is *depression* of the circulation, both as to force and rapidity; but such depression is often preceded by a rise in the pulse-rate, and a similar rise may occur before death in the later stages of poisoning.

Ackermann, indeed, experimenting upon healthy men with emetic doses (about ¾ gr. of the tartrate), found a *prolonged rise* in the pulse-rate, to an average maximum extent of 42 per minute, and this was distinctly related to the gastric symptoms. The rise began only with the onset of nausea, and increased with the occurrence of vomiting, after which the pulse fell to an ordinary level: it became also soft and weak in proportion to its quickness, but he did not observe any decided fall below the normal rate at any period (Abstract, Brit. and For. Rev., April, 1859).

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These observations were carefully made, the pulse being examined every five minutes for several hours, but they illustrate only the effect of one or two doses. There can be little doubt that a longer course of the same, or a larger initial dose, would have induced the slowing of pulse which has been verified by so many observers; but we may note a parallel observation made by Trousseau, that in some few persons taking antimony the pulse became and continued quick, as well as weak and irregular. Usually, as at first stated, slowing of the pulse is a marked and somewhat persistent effect of antimony, and especially so when vomiting does not occur at all, or after it has ceased: from six to ten beats per minute is an average amount of decrease after doses of 1 to 2 gr., but it may vary from three beats to forty (Pécholier, Bonamy). Gubler has noted a proportion between the ultimate fall and the primary increase. (Whether such primary increase, when it occurs, is due to a temporary excitation of the whole system, or to paralysis of the regulating branches of the vagus, has been a question: the former is, I think, more probable). Arterial pressure is much diminished, and the curves of a sphygmogram may be almost effaced (Bordier): more or less venous congestion also occurs.

After very large doses, any acceleration is but slight and transient, before the blood-current becomes slow and almost imperceptible. In frogs, dogs, or rabbits, when a sufficient dose has been introduced by any channel, the cardiac contractions also soon become slower, weaker, and irregular, the auricles contracting oftener than the ventricles. When death occurs from the drug it is said to be always through cardiac palsy (Richardson), the general state of collapse being secondary to failure of the circulation. Arrest finally occurs in diastole, and the irritability of the cardiac muscle is found to be impaired or lost (Radziejewski, Bellini), probably owing to a directly paralysing influence on the cardiac muscular structure when reached by the drug after absorption. When antimony is applied to the batrachian heart, removed from the body, similar slowing and arrest take place, which is another reason for considering the action to be directly on the muscular structure. It is curious that in animals subjected to toxic doses, death can be delayed for some hours by dividing the vagi (Majendie).

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Rabuteau notes the remarkable analogy between the above action of antimony, and that of digitalis. Nobiling traced the depressant effects described to the potash, rather than to the antimony in tartar emetic, but his observations have been disproved.

Respiratory System.—In the experiments of Ackermann, the number of respirations increased in direct relation with the increase in the pulse-rate, but under the continued influence of the drug, independently of irritant effects, and of any preventing lung-disorder, the rate of respiration is slowed. It may be so by as much as half or two-thirds the normal rate, so that only six respirations occur per minute, and this without general distress or impairment of other functions (Trousseau).

After poisonous doses, the breathing is very irregular, at one time hurried, short, and painful, at another, extremely slow, with laboured and forcible inspiration and expiration: this is due in part to paralysis of the heart and other muscles, in part to impairment of reflex sensibility and to altered conditions of the blood. After death in such cases, Majendie, finding the lungs partially congested and hepatized, concluded that the action of antimony was specially exerted on these organs, and Mayerhofer certainly proved its elimination by their mucous membrane: ecchymoses and emphysema are found when the act of breathing has been very laboured.

The effect of the drug upon the excretion of carbonic acid has been differently stated: some observers report it lessened in amount (Coze, Mialhe, Rabuteau), but recent writers (Ringer, Bartholow) express an exactly opposite opinion, though neither gives his original authority (*v.* p. 365). Further accurate observations upon this point are admittedly wanting, but having regard to the sedative effects of sufficient doses, independently of inflammatory action, the former statement seems to me more in accordance with known facts. That *arsenic* lessens the excretion of carbonic acid is now recognized, and though Gubler holds that we do not know enough of arsenical action to make the analogy of scientific value, I should hesitate before ascribing to so closely an allied

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drug as antimony, a directly opposite effect in this important particular.

Digestive System.—Upon the alimentary tract, antimony acts as an irritant in greater or less degree, according to the dose: $\frac{1}{30}$ to $\frac{1}{15}$ gr. of the tartrate, or even less when repeated, will induce some sense of warmth in the stomach, and some increase of its secretions; $\frac{1}{8}$ to $\frac{1}{4}$ gr. will cause, in addition, a feeling of soreness, a flow of saliva, impairment of appetite, and possibly nausea; $\frac{3}{4}$ to 1 gr., given in a glass of water, will usually induce vomiting within fifteen to thirty minutes. The vomiting is distressing in character, accompanied with shivering, much depression, retching, and persistent nausea: the ejecta contain mucus, and later, bile. The same dose generally purges, and if taken with a *large quantity* of water will be almost sure to do so, either with or without vomiting. The evacuations at first are simply fluid, then mixed with free bile, and are passed with some straining and griping pain. It is noteworthy that a larger dose is required to produce these effects when given by intravenous injection than by the stomach.

Large doses of 10 to 20 gr. or more, act very severely; the local irritation and burning pain are great; vomiting occurs quickly and with much distress; there is difficulty in swallowing, spasm of œsophagus, severe tenesmus and cramp in the abdominal muscles, and profuse diarrhœa of sero-albuminous fluid, containing flocculi of detached epithelium (like the rice-water stools of cholera), and sometimes blood.

In fatal cases the mucous membrane of the stomach and of parts of the intestine, especially the lower portions and the rectum, has been found acutely congested or inflamed, softened, aphthous, or ulcerated.

Conditions modifying the Action of Antimony — Tolerance, etc.—The preceding description requires to be qualified, especially in cases of what is called "tolerance." If the giving of antimony be commenced in fractional doses, and continued with very gradual increase, it is possible to produce full sedative effects without gastric disturbance. Again, in certain forms of illness, with altered hæmatosis, such as pneumonia, or in some nerve-disorders, as chorea or delirium tremens, full doses may

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be given without any evidence of irritation, and then "tolerance" of the drug is said to be established. Further, in some instances, ½-dr. and 1-dr. doses have been taken without vomiting (Hicks, Lancet, ii., 1876, p. 38), and in other cases of poisoning from very large doses, the prominent symptoms have been those of collapse, and the patient has died without vomiting or purging, or complaint of pain. Indeed, not the least of the difficulties in studying the action of antimony, we find in the circumstance that sometimes there is no post-mortem evidence of irritation or inflammation to be found, either in stomach or intestine (Handfield Jones, Bellini, Böcker). As with other powerful drugs, there may also exist some idiosyncrasy in certain persons, leading to difference in result that we cannot otherwise explain, but the account I have given represents the effects as usually observed: as a rule, it acts with most intensity on the delicate, on women, and more especially on children, and in these subjects "tolerance" is less easily induced than in men, and lasts for a shorter time. When tolerance has once ceased, great care must be exercised in resuming the drug, for it will more readily excite gastric derangement (Trousseau).

Glandular System.—Moderate doses increase the secretion of the parotid, the pancreas, the liver, and the gastric and intestinal glands, the drug acting as a stimulant or irritant during its elimination by these structures.

The increased secretion has been variously attributed to irritation of the gland-cells, and to paralysis of their controlling nerves: the former is the primary, the latter a secondary effect.

Cutaneous System.—Whether it has a like action on the sweat-glands has been disputed, and the increased perspiration which commonly follows its use has been attributed to the act of vomiting, or to the course of an illness (Trousseau). It is true that when the remedy is "tolerated" there is usually little sweating, but this need imply only that under certain conditions less of the drug is excreted by the skin. In my own experience, diaphoresis has occurred clearly from antimonial action, independently of vomiting, and this seems quite in accord with the increased secretion from other glands. (I do not here refer to the profuse cold sweating of later stages of poisoning,—the result of exhaustion.)

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Neither do I see any difficulty in accepting the (few) recorded cases of pustular eruption following the internal use of antimony (Gleaves, Böcker, Mayerhofer, Taylor). The drug is certainly eliminated in greater or less extent by the skin, and that it may sometimes cause suppuration is not more unlikely than in the case of iodide of potassium.

Urinary System.—There is difficulty in estimating exactly the effect of antimony on the kidneys, and statements with regard to it vary much. It is probable that more or less of the drug may be excreted by this channel, according to circumstances, for, as already stated, Mayerhofer, experimenting on himself, could, at one time, detect it in his urine, and at another time, not; he found the amount of urine at first increased, afterwards lessened. Trousseau and Gubler report a marked increase in the secretion only when vomiting and purging were absent or slight, and this was the case also in Hannon's experiments.

If the circulation be extremely depressed, or if choleraic symptoms occur, the urine is likely to become scanty, or even suppressed.

Other observers distinguish between the different constituents of the urine; Böcker, taking himself 2½ gr. daily for nine days, found the urea and other urinary solids markedly lessened, and Beigel, giving a similar dose to four patients for four days obtained the same results: in both instances, comparatively little food was taken.

Dr. Parkes, however, found the amount of urea increased after sulphuret of antimony, and several modern writers (Ringer, Bartholow) describe a similar increase, relying, probably, on, the observations of Ackermann. His subjects received a cup of coffee, and then remained in bed for a day, taking from 1 to 2 gr. of tartar emetic, which caused emesis and often purgation. He reported that the water and the chlorides were diminished in proportion to the diarrhœa, but urea was increased by one-eighth, or even one-fourth, and uric acid and pigment were also increased: these results he attributed to increased metamorphosis. I cannot, however, accept them as conclusive evidence of the full action of antimony, for the lowering of circulation and of temperature, and relaxation of vessels, and the analogy of allied medicines (arsenic, digitalis) suggest so forcibly an opposite

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conclusion (*v.* p. 362). Further experiments are required on this point: meanwhile, I cannot but agree with Rabuteau and others in classing the drug with those which moderate or diminish the nutritive processes, and which therefore tend to lessen the excretion of urea as well as of carbonic acid. As a curious illustration of the power of antimony to lessen excretion and lower true nutrition, we may refer to a custom common in Germany of using "glass of antimony" in the food to fatten fowls and animals.

Temperature.—There is a similar discrepancy in observations on temperature,—a discrepancy which must depend upon difference in dosage, or in continuance of the medication, or in the reaction of healthy as against weakly subjects. Thus, Ackermann found the hands and face become cold during the period of nausea, but after vomiting they became warmer, and the mouth-temperature did not fall, but increased about 1° F.

Dr. Ringer made a very complete experiment when he gave ½ gr. of tartar emetic every ten minutes for seven hours, inducing vomiting and sweating, and yet the temperature did not vary more than 0·4° F. On the other hand, Pécholier observed the temperature to fall in direct ratio with the pulse, and the amount of fall has been stated at from 1° to 3° C. (Hirtz, Gubler): a brief and slight preceding rise has been noted by the latter physician.

In cases of *poisoning* the depression of temperature is very marked, and in another series of experiments made by Ackermann on animals, it amounted to nearly 7° C. in those that survived a *few* hours.

Nervous and Muscular Systems.—These systems are first excited and then paralysed by antimony in varying degree according to the dose and the amount of gastric irritation. Restlessness and pain may be at first marked with general tremor and spasmodic contraction of the muscles, either of the abdomen, the jaw, the œsophagus, or extremities, especially of the hands (case of Mrs. Prichard, etc.—cases by Orfila, Elliotson, etc.).

In animals, reflex sensibility is much diminished (Radziejewski), and some degree of motor palsy occurs: these effects,

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so far as they are central in origin, are spinal rather than cerebral, for they occur equally when the cerebral centre is separated.

They have not been so marked in man, but great muscular prostration is quickly induced, and profound collapse is a characteristic symptom of antimonial poisoning: in some exceptional cases it has been more marked than any irritant symptoms.

There may be temporary loss of consciousness and semi-narcotism (case of Mr. Bravo), or convulsion, and later delirium (Orfila), but usually the mind remains or becomes clear before death.

Fatal Dose.—The minimum fatal dose for an adult may be stated at 2 gr.; for a child, $\frac{3}{4}$ gr.

The post-mortem appearances have been sufficiently indicated. We need only note further confirmatory evidence of the power of antimony to produce fatty degeneration in the experiments of Salkowski, who found this change in the viscera of animals after adding 8 to 15 gr. per diem of an antimonial compound to their ordinary food.

Theory of Action.—There has been much discussion as to whether the vomiting and purging which are produced by antimony are due to direct gastro-intestinal irritation, or are secondary to an influence exerted on the nerve-centres (medulla oblongata) by the drug after absorption. The former view was commonly accepted until Majendie's experiment of substituting in an animal a bladder for the natural stomach, and then causing vomiting by intravenous injection of antimony. Such an experiment seemed to prove that emesis was effected through the nerve-centres independently of the stomach; and besides this, the persistence of the nausea seemed to indicate more than an ordinary (mechanical) irritation. Chouppe has also concluded from recent experiments that although antimony may act by such irritation, it more usually acts after absorption. He divided the vagus nerve in dogs; and after subsidence of the retching from the operation, injected antimony into the cellular tissue or veins, and vomiting followed as usual: as an experiment for contrast, he injected in other dogs emetine, and when the vagi were divided this caused no vomiting (Abstract,

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Lancet, ii., 1874, p. 532). Broussais and others, however, always maintained the earlier views as to local irritation, and they are further supported by the following evidence:—(1) Emesis has occurred before any antimony could be detected in the blood (Mayerhofer). (2) In several instances nearly the whole of a dose of antimony has been recovered from the vomited matters—implying that very little, if any, absorption could have occurred before vomiting (Radziejewski). (3) In almost all fatal cases, marked congestion or signs of irritation have been found in the *stomach* after death, and this even when the drug has been given by the veins or other channels. It has clearly been proved that elimination occurs from the gastric membrane under such circumstances, and it is probable that in Majendie's experiment, the drug was eliminated by the pharynx and by the intestine, and produced vomiting just as if introduced into the natural stomach (Hermann, Grimm, Brinton, Richardson). (4) A smaller dose will produce vomiting when given by the mouth than when given by the veins; this seems a crucial experiment on the point, and although an opposite statement has been made by some observers, it has been verified by Hermann, Grimm, Kleimann, etc., and it is agreed, of course, that general symptoms occur also after, and in consequence of, absorption, and that nausea and prostration are prolonged in consequence of such absorption.

Another question is, whether the deeply-depressing effects of the drug are due to a special "contra-stimulant" action (Rasori), or whether they are only secondary to the emeto-catharsis (Broussais). I must conclude also on this point, that without denying a depressant effect after absorption, and poisoning of the nerve-centres, the muscular tissue, etc., yet the early depression and collapse depend rather on the gastric irritation, the nausea, and the vomiting, and are due to reflex action on the sympathetic and pneumogastric centres. We know that nausea from any cause is accompanied with prostration, faintness, chilliness, and pallor, and antimonial nausea causes the same symptoms in a similar manner, without invoking any speciality in its action (Gubler).

Tolerance, we may explain in some instances, perhaps, by the fact of only partial absorption occurring, *e.g.*, through deficiency

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in the gastric secretions during fever; but this will not explain it so completely as some have supposed, because the induced feebleness of circulation and respiration, and occasional occurrence of organic lesions, prove that sufficient absorption must have taken place to cause the ordinary effects.

A more reasonable explanation is to be found in the *impaired nerve-condition*, and especially the diminution of reflex excitability in the subjects of "tolerance."

We may say that all those in whom it is evident *at once* (so that they bear "Rasorian" doses of one or more drachms without any pain or vomiting), are either suffering from some neurosis of stomach or vagus, or from some grave malady, as pneumonia, which clearly lowers their vital power: and in those persons in whom tolerance has been slowly induced by the gradual increase of small doses, we may presume that antimony has exerted its known power of diminishing reflex activity, and has thus reduced the patients in this respect to the condition of invalids, even if in other respects convalescent.

Moreover, in many cases of tolerance, though there has been no vomiting, yet diarrhœa has occurred, and the absence of *vomiting*, which is a complex act, may simply mean that reflex nerve-power is too much impaired for its production, diarrhœa being a simpler process.

In women and children, reflex nerve-activity is higher than in the average man, which fact would, according to the previous hypothesis, explain why tolerance is less readily induced in them.

SYNERGISTS.—Other emetics, such as ipecacuanha, and other purgatives, such as calomel, increase the effects of antimony. Sedatives, such as bleeding, and more especially digitalis and veratrum, have an allied action: also other medicines which under certain circumstances quiet febrile excitement, as quinine in full doses, arsenic, bromides, citric and tartaric acids.

ANTAGONISTS AND INCOMPATIBLES.—Aromatic, alcoholic, and other diffusible stimulants counteract the depressant effects of antimony. Narcotics, and especially opium, hinder its special action (Rasori)—Gubler, indeed, calculates that opium

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lessens its power by one-half, and considers it much better to give a half-dose in any case, or to give the narcotic separately, than to combine such antagonists. Graves, however, has proved a clinical value in the combination, and Laennec found antimony better borne when conjoined with opium and aromatics.

Cold acts as a partial preventer of vomiting, and warmth, of diarrhœa.

Mechanical antidotes are such as oil, thickened milk, and mucilaginous substances: and tannin, in all its forms, is a powerful *chemical* antidote: decoctions of oak and cinchona bark, gall-nuts, strong tea, etc., may be used, and life has been saved by these agents in apparently hopeless cases of poisoning.

THERAPEUTICAL ACTION. — *External.* — The ointment acts as a strong local irritant, and was much employed when counter-irritation was more highly esteemed than it is at present. The pustulation caused by antimony is more painful, but perhaps more permanent in its good results, than that produced by croton oil.

Phthisis.—In the earlier stages of this disease, when there is evidence of local lung-congestion, with pain and oppression, and in the later stages when acute general symptoms are not urgent, I have known it serviceable. Dr. Hogg recommended its application on plaster, sprinkling about 4 gr. of finely-powdered tartar emetic upon the surface of an ordinary warm "pitch-plaster:" in the course of a few days this produced much irritation and a crop of pustules. It seems rather severe treatment, but is sometimes beneficial (Brit. and For. Rev., ii., 1860, p. 382).

Meningitis — Hydrocephalus. — In these maladies, the ointment has been applied over the shaven scalp, but the results certainly do not compensate for the suffering caused.

Orchitis—Ovaritis.—Frictions with the ointment have been made in orchitis, along the line of the spermatic cord as far as the scrotum, the skin having been previously punctured. M. Isaac reports well of this procedure (Practitioner, 1869), but I cannot think it desirable; it has proved unsuccessful under my own observation. Dr. Rigby speaks very highly of the good

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effect of counter-irritation by antimonial ointment in ovaritis (Diseases of Women).

Nævus.—Mr. Bateman recommends a resin plaster made with two parts to one of tartar emetic, and applied over the nævus until inflammatory action and pustulation occur (Lancet, ii., 1869). I have several times pursued with success a similar plan.

Lupus—Cancer.—The chloride of antimony has been employed as a destructive caustic for these growths, but is now practically superseded.

THERAPEUTICAL ACTION.—*Internal.*—The double power of antimony to control circulation and nerve-excitement, at the same time that it increases secretion, indicates its use in many diseases, and especially in those of febrile and inflammatory character; on the other hand, the extreme depression that may be caused by it has led to serious results in incautious hands; hence much controversy as to the true value of the drug, and whilst by some writers it has been extolled as the best of remedies, it has been described by others as too dangerous a poison to be used.

Forbidden in France by special law in the sixteenth century, it was, not long afterwards, received into the Codex, and about the same time our "Earl of Warwick's powder," consisting of the sulphuret of antimony, with cream of tartar and scammony, obtained a wide reputation. The tartrate of antimony and potash was introduced somewhat later (by Mynsicht), and has continued in general estimation and daily use down to our own time.

Within the last twenty years, however, and since the value of tonic and restorative treatment has been better recognized, antimony has, like bleeding and other depressants, been more rarely prescribed, and at present it may be questioned whether its great therapeutical powers are sufficiently appreciated. We do not hold that this, more than other medicines, has a separate or specific action for each of the various diseases we are about to mention,—that it cures convulsion in general, or pneumonia, or rheumatism as separate nosological species (Gubler), but rather that it exerts an exceptionally marked influence on certain pathological states, which either cause or complicate these and many other maladies.

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Fevers.—At the commencement of an attack, when gastric disorder was very marked, an antimonial emetic was formerly much commended. Dr. Gregory often employed it in these circumstances, but he also pointed out the danger of inducing irritability of the stomach, and even inflammation. Dr. Graves and others have taught that such an emetic, given within thirty-six hours of the initial rigor, would often abort the fever, but this is difficult to prove, and is not generally accepted. Modern practice has rather taught us that nausea and vomiting are usually needless annoyances to the patient, though if induced in the early stages vomiting may certainly relieve headache and severe gastric congestion when dependent upon accumulated mucus and bile.

Dr. Graves originated, and highly praised also, the administration of antimony in fever (especially *typhus*) at a stage when cerebral complications are sometimes very severe, *e.g.*, from the seventh to the ninth day. Thus, to a strong adult, suffering with complete insomnia, illusions of the senses, delirium, continued tremor and subsultus, "cerebral" respiration, very quick and weak pulse, sordes, and every symptom of the worst augury, ¼ gr. of tartar emetic in water was given every hour: the patient vomited freely (though not directly) after each of the first four doses, then purging began, the general condition improved, and the man slept: after temporary omission of the medicine, 2 min. of "black drop" (opium) were given every two hours, and on the following day there was free perspiration, natural sleep, and a rational mind: ultimately a good recovery followed (Clin. Lectures).

In other equally severe cases the same dose of antimony has been given from the first with 2 or 3 min. of laudanum, and the results have been such as to warrant much confidence in this method of treatment; it is necessary, however, to use it cautiously, and to bear in mind its weakening effect upon the cardiac muscle, which is already enfeebled from the effect of the disease (Murchison).

Enteric Fever—Antimony has been commended in this fever, but the intestinal condition requires exceptional caution in its use; it does not of itself forbid the remedy, for diarrhœa and pain have often subsided under it (Trousseau), and when the lungs are implicated it may be especially useful.

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M. Bériard records a case of fever with secondary pneumonia and delirium, rapidly passing into a hopeless comatose condition, which was relieved at once by free vomiting and purging from a large dose (nearly 6 gr.) of tartar emetic, and ultimately recovered (Bull. de Thérap., 1873).

Intermittent Fever (*Ague*).—The paroxysms may sometimes be prevented by an emetic dose of antimony, but this is not a special effect of the drug, for it will occur after the use of other emetics.

Scarlet Fever — Measles — Small-pox. — In these disorders, especially when the eruption is scanty or suppressed, antimony may be useful by determining to the skin, and thus relieving the febrile condition and obviating grave symptoms.

I have given tartar emetic in small-pox in varied doses, but have never known it exert a modifying influence on the disease itself. In certain complications, however, such as pneumonia, bronchitis, or acute delirium, doses of $\frac{1}{16}$ to $\frac{1}{4}$ gr. every two or three hours, have given relief.

Antimony is exceedingly useful in the bronchial catarrh which is often a serious complication of measles: besides controlling the general pyrexia, it relieves the oppression of the chest, acts as an expectorant, and tends to diminish a too abundant secretion of mucus, probably by lessening congestion.

If $\frac{1}{2}$ gr. of tartarated antimony be dissolved in 4 oz. of distilled water, a teaspoonful may be given frequently or occasionally, according to the severity of the cough or the oppression. In the case of weakly children, the amount of depression which may be induced requires to be carefully watched.

"Worm-Fever."—In remittent pyrexial conditions dependent upon intestinal worms, I have found small doses beneficial, but the emetic action of the drug, as a rule, is undesirable.

Rheumatic Fever.—Laennec, Bricheteau, and other eminent physicians of a past generation, advocated the use of large and repeated doses in acute rheumatism, but later experience is against their adoption. I formerly used $\frac{1}{4}$-gr. doses with advantage, especially when the temperature was not very high. Barbeau quotes cases illustrative of its value in acute rheumatism, when used as an evacuant previous to commencing quinine (Med.-Chir. Rev., i., 1857, p. 266).

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Lumbago.—In obstinate cases of ordinary lumbago and local muscular rheumatism, I have ordered the same dose every one or two hours for a short time with excellent results.

Erysipelas.—Desault recommended the frequent use of minute doses of antimony in erysipelas, giving 1 gr. dissolved in a quart of water in the course of twenty-four hours. Dr. A. J. Walsh has reported a number of satisfactory results under this treatment (Dub. Quart. Journ., Aug., 1850), but I consider other remedies act still better (*v.* p. 591).

Traumatic Pyrexia.—In febrile conditions resulting from severe injury, antimony has been found useful. Thus, Mr. Denny found it "act like a charm" in a case of gun-shot wound of the chest with inflammatory reaction, rigors, delirium, etc.: some nausea was induced, the pain quickly subsided, and in twelve hours the fever aborted, and sleep set in (*B. M. J.*, i., 1871). Speaking, however, from large experience, I am satisfied that aconite is a more trustworthy remedy in such cases.

Acute Inflammations—Orchitis, Tonsillitis, etc.—In minor local forms of inflammation, such as of the breast or testicle, of the tonsil or parotid, or of a varicose vein, the good effect of small doses of tartar emetic is often conspicuous. Dr. Beatty especially noted their power of controlling mammary inflammation, as if by "specific action on the gland." After purgation, he gave $\frac{1}{16}$ gr. every hour, never desiring an emetic action, but not objecting to slight nausea (Dub. Journ., vol. iv.). Dr. Churchill found the same plan "more effective than any other" (Midwifery). A case of inflamed varix cured by this method is related by Dr. Spender in his essay on the advantages of small, frequent doses (Brit. and For. Rev., 1872), and he believes that the dose may be adjusted with mathematical precision and certainty: "$\frac{1}{20}$ to $\frac{1}{16}$ gr. given every hour is bound to control a local phlegmon." I have found it good in tonsillitis and parotitis, the pain, congestion, and pyrexia being often quickly relieved, and yet this is not the treatment I usually adopt, nor do I think it so good as that by aconite or belladonna.

Purulent and Strumous Ophthalmiæ.—In these affections, tartar emetic was a usual remedy some years ago, and doubtless acted by abating local congestion; modern practice,

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however, places more reliance on the use of topical remedies and of tonics.

Acute Eczema.—When this malady occurs in persons of full habit—especially if also of gouty tendencies—and when pyrexia, severe local irritation, gastric disorder, and loaded urine are present, I have seen much advantage from combining antimony with magnesia or other saline aperients, or with diuretics. Meade also writes in its favour (B. M. J., ii., 1864).

Bronchitis.—Tartar emetic seems to me to exert almost a specific effect on inflamed bronchial membrane. In the case of old people it is useful especially when the cough is convulsive in character, most troublesome at night, and attended with loud wheezing respiration, paroxysmal dyspnœa, and profuse secretion of mucus which is, with difficulty, expectorated. When inflammation affects the smaller tubes of young adults, an emetic dose may be found sometimes desirable, but as a rule, $\frac{1}{16}$ to $\frac{1}{8}$ gr. every two to three hours will suffice to render free and less tenacious the bronchial secretion, to lower the blood-tension, diminish pyrexia, and relieve local congestion and oppression. The action of the skin and of the kidneys is increased usually in inverse ratio—if one is more, the other is less marked. If cough be very severe, a little morphia or belladonna may be combined with the antimony, whilst in later stages, if more stimulus to expectoration is needed, squill is a useful adjunct.

In the *capillary bronchitis* of children, tartar emetic often proves valuable. I have treated with it nine cases during the last season; all were under two and a half years old, and suffered with distressing paroxysmal cough, which caused much exhaustion; the respiration was much quickened, the pulse 130 to 140, small and feeble, the temperature 101° to 103° F.; there were the ordinary physical signs in the lungs, the face was dusky and œdematous, the skin covered with a clammy moisture; restlessness was extreme, and cerebral symptoms, such as sopor, delirium, and even (in some) coma, were present; these patients were ordered small but frequent doses, $\frac{1}{64}$ gr. every half-hour for four doses, afterwards every one to three hours, according to the amount of cough or oppression: of the nine cases, four vomited within

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two hours of the first dose, and all showed signs of exhaustion under the medicine, but all of them made good recoveries.

Pneumonia.—The proper treatment of this disease has long been a crucial question, and opinions have varied as to the amount of influence possessed over it by antimony. Very much depends upon the time and mode of administration. Rasori, with his "contra-stimulant" method, aimed at exciting, in or near the inflamed part, an artificial irritation, more powerful than the original disease, and gave from the commencement large doses, which he rapidly made enormous. Thus, one adult was ordered on the first day about 24 gr., and by the eighth, 144 gr. per diem; the amount was then reduced up to the twelfth day, when death occurred: the same patient was bled several times in the course of the attack, this being considered to favour the special action of the drug; there was no evidence of its irritant effect, but such a mode of treatment could not be sanctioned at the present time; and although the mortality in the practice of the Italian physician was less than that of his contemporaries, it was yet very large, and must not be taken as illustrating the results of a judicious use of antimony.

Laennec usually recommended 1 gr. every two hours till 6 gr. had been taken, and then an intermission for the same period; sometimes, however, he increased the dose gradually to 30 gr. in the twenty-four hours. His mortality was about one in twenty, reckoning only well-marked cases; that of Louis, following a very similar method, was about three in twenty. Trousseau and Grisolle, who have treated the subject fully, agree in speaking highly of *this* antimonial treatment, the former, indeed, so highly, that he foresees "a future generation will tax him with exaggeration." The latter observer has specially analysed forty-four cases, showing some strikingly good results as to relief of signs and symptoms and as to brief duration, but these reports must be read in the light of our later knowledge of the *natural history* of pneumonia, which would explain some of the rapid recoveries by the occurrence of a natural crisis: vomiting and purging were often caused to a serious extent (cf. Sturges, On Pneumonia, Appendix G, "Treatment Statistics").

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Dr. W. Stokes was one of the earliest British physicians to report favourably of this remedy in pneumonia; he stated that it acted better when given before hepatization had commenced than afterwards. Sir Thos. Watson also commends it, specially in the stage of engorgement, and Dr. Walshe lays stress upon its value when it is not given to emesis. Dr. C. J. B. Williams uses $\frac{1}{8}$ to $\frac{1}{2}$-gr. doses every two, three, or four hours during the early stages, combining them with citrate or nitrate of potash (Lectures, Med. Times, i., 1872).

Three grains is the minimum, and 16 the maximum daily dose recommended by the German Codex, and these quantities nearly accord with those already mentioned: with them vomiting has generally been observed at first, and is said to have proved useful rather than otherwise, and later on, tolerance has become established so that irritant effects have not been marked; nevertheless, smaller doses are to be preferred. I have found the best results from those ranging between $\frac{1}{50}$ and $\frac{1}{4}$ gr. given every two to three hours, beginning with the smaller amount and increasing gradually so as to produce general effects without vomiting or even nausea. In severe cases, with high temperature, small frequent doses of *aconite* are valuable in combination or alternation with antimony (*v.* Vegetable Kingdom), and I believe by this treatment may be effected all the good Rasori expected from preliminary bleedings. In moderately severe attacks, with less pyrexia, antimony alone is a good and sufficient treatment from the first, although its special value is shown best when "resolution" begins; it assists the clearing up of consolidated lung. Another indication for the remedy is to be found in the presence of various complications, such as bronchitis, or whooping-cough, or when the malady deviates from an ordinary course, or occurs after influenza or in emphysematous subjects; then I have reason to express the greatest confidence in it. It is true that Nothnagel, Nöbiling, and others, hold a different opinion, but this may be attributed partly to giving larger doses than the patients could bear, partly to the indiscriminate use of the medicine in all stages and phases of

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the disease; for Nöbiling speaks of emetic doses which induced *cardiac collapse*, and of small doses being continued till *intestinal ulceration* occurred, results of which I have never seen any indication under the method above recommended. I must, however, guard myself from seeming to imply that it is the only or the best treatment for every individual case: in exhausted broken-down subjects the appropriate time for it is but short, and ammonia, bark, phosphorus, and alcohol must soon replace it, whilst in septic forms of the disorder, which indeed are not infrequent, tinct. ferri perchloridi is rather indicated.

In the serious *lobar pneumonia*, as it commonly affects young children, many authors—Stillé, for instance—question the propriety of giving antimony in any dose, because of the risk of sudden depressing effects; this must be borne in mind, but yet I have myself seen the remedy so efficient that I advise its employment very much as in the lobular form connected with capillary bronchitis.

Dr. George Buchanan, whilst hesitating to recommend antimony as a usual treatment, records that he has seen more benefit from emetic doses of it given at an early period ($\frac{1}{6}$ to $\frac{1}{4}$ gr. every quarter-hour till vomiting occurred), than from any single remedy; it seemed to control the severe symptoms, and secure a favourable after-progress (Lancet, i., 1868); this is, of course, one mode of using the drug, but I prefer minute continued doses.

In cases of *phthisis with intercurrent acute pneumonic attacks*, the remedy is often as useful as in the idiopathic malady, but special care must be taken to avoid emetic or irritant effects, because of the possibly tuberculous condition of the intestine. In "incipient phthisis," during the stage of cachexia with febrile reaction, small doses lessen irritation and congestion; and even in the developed malady, when there is general pyrexia, and constant irritative cough, it often relieves, rendering the cough "softer" and expectoration easier.

Inflammatory or True (Membranous) Croup.—In this serious disease antimony often proves useful, especially in the early stages. It first obtained its reputation at a time when

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spasmodic and catarrhal croup were not well distinguished from the more serious malady, and when recovery from those varieties was reckoned as recovery from true croup; but at present, on account of its depressing effects, most physicians limit its use to a few emetic doses in cases with very severe spasm, and evident obstruction from false membrane (Klemm, Schmidt's Jahrb., Bd. clx., s. 45). Dr. Elliotson, however, records cases occurring in infants, and treated successfully with ¼ and even ½-gr. doses every four hours—in one case 27 gr., and in another 33 gr. being taken: vomiting occurred, and some tetanic spasm, but good recovery was made from critical conditions. Mr. Meek and others report in the same journal cases where ½-gr. and even 1-gr. doses were given with favourable results to children of four and seven years; but, on the other hand, Mr. Kesteven and others record injurious effects (Med. Times, ii., 1856). Professor Bouchut advocates giving $\frac{1}{6}$ to $\frac{1}{3}$ gr. frequently, until emesis and diarrhœa are produced, and he records several cases of recovery in the second and third stages (Journ. f. Kinderkn., May and June, 1861, Lancet, ii., 1872).

I cannot adopt the above doses as quite safe, and think that great caution should be exercised as to their use. I recommend rather a solution to be made with 1 gr. in 4 oz. of water, and of this one teaspoonful ($\frac{1}{24}$ gr.) may be given every half-hour for four or five doses; it will often suffice to excite vomiting, which, however, is not desirable unless there be evident obstruction in the trachea; so soon as this obstruction is lessened, the remedy should only be given at intervals of two to three hours: the dyspnœa is commonly removed for a time after vomiting, but if it recur, the same effect should be induced again: of course, the patient's strength is to be supported by suitable nourishment, and fomentations, sprays, or other adjuvants may be used. With this plan of treatment I have many times noticed an early abatement of the cough, dyspnœa, and hoarseness, lowering of the pulse-rate, return of natural warmth and colour, and quiet sleep. It is true that the sulphate of copper is often preferred as an emetic, but under the sole use of antimony, as described, I have seen very severe and advanced cases relieved, and if the dose mentioned be found really too small in a given instance, it may be cautiously increased.

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Nephritis.—In acute nephritis, whether induced by cold or by fever, antimony has been specially commended by Dr. Bence Jones, Dr. Barlow, and others (Guy's Reports, vol. x.). It would certainly seem, *à priori*, that the action of small doses on the skin and the intestinal tract, as well as on the inflamed organ, should be of favourable character, but practically I have seldom found it to be so. Tartar emetic does not appear to exert any direct special power in controlling disease of the genito-urinary mucous membrane.

Spasmodic Croup—Laryngismus Stridulus.—Antimonial emetics have been very strongly recommended to arrest the paroxysms of this malady (Stillé), but yet, remembering its clear connection with rachitis and impaired nutrition, tartar emetic is not the remedy we should choose for curing its essential cause: bromides, belladonna, and cold bathing, with tonics and nutrients, are more indicated.

Muscular Spasm—Rigidity of Os Uteri—Colic.—Muscular spasm, such as occurs in dislocations, herniæ, etc., may certainly be relieved by emetic or nauseant doses of antimony, and these were, at one time, commonly employed.

In difficult labour connected with rigidity of the muscular structure of the cervix uteri and perineum, relief may also be given by the same means. Dr. Kennedy, of Dublin, strongly recommended this treatment, and Dr. Gilmour (Liverpool) quoted a large experience in its favour; he claimed for it also, not only an immediate favourable effect, but a good influence on the after-progress of the case, finding marked freedom from subsequent inflammations, etc., where it had been used (Lancet, ii., 1852): practically, however, chloroform has superseded it.

For **Intestinal Colic**, tartar emetic has sometimes been given successfully by enema. In a case dependent upon obstruction, 3 gr. dissolved in 8 oz. of water were injected per rectum, and, after some hours, the obstruction yielded and the colic subsided, without additional nausea or prostration (Lancet, i., 1856, p. 96.)

Constipation.—In obstinate cases connected, in part at least, with deficient intestinal secretion, and occurring especially in old people, small doses of tartar emetic will assist the action of

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saline purgatives such as sulphate of magnesia. Dr. Nevins has recorded a good illustration of this, and finds that less than ¼-gr. doses will usually suffice (Comment., Lond. Pharm.).

It has been maintained by some distinguished writers (Gubler, Chomel, Rayer, etc.), that not only the above-described but all other therapeutical effects of antimony are dependent upon, or connected with, its emetic, or at least its nauseant action, and are explained either by an elimination of morbid material, or by the profound disturbance and subsequent reaction induced in the economy; but—not to speak of the older cases in which benefit was conferred during "tolerance," *i.e.*, when there was little or no vomiting—I am satisfied that most maladies are better treated by small and frequent doses, which do not cause vomiting, and that only a few cases require the production of nausea.

Mania—Melancholia.—There can be no doubt that the large doses—12 to 30 gr.—formerly given to patients with mental disease, and especially to those suffering from acute or violent mania, served the purpose of quieting their violence for a time, but the general results were rather injurious (Greisinger), and professional opinion is justly opposed to producing temporary quiet by this means (Bucknill). A smaller quantity, however—½ to 1 gr., thrice daily—I have often known to be well tolerated by men who are in fair bodily health, and it certainly acts better when nausea and depression are not induced. The same observation has been made by Schroeder van der Kolk, a deservedly high authority: he has seen marked benefit from the remedy, and recommends it in pill after meals (to avoid vomiting), the dose to be cautiously increased from ¼ gr.

In **Puerperal Mania** the last-named physician has also found small repeated doses very useful, and Dr. E. Kennedy recommends them especially for phlegmatic patients (Amer. Journ., v. 17). Dr. Madden has seen doses of ⅛ gr. every four hours act very favourably, subduing delirium in a comparatively short time; sometimes he has used doses of 1 gr., which quieted excitement still more quickly, but were liable to depress the heart-action unduly (Med.-Chir. Rev., ii., 1871).

Puerperal Convulsion.—For convulsions occurring in vigorous, muscular subjects, with high arterial tension, it is

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possible that antimony may be sometimes indicated. It has been, with advantage, combined with bromide of potassium (Practitioner, ii., 1869). Before the latter drug came into use, I often had recourse to antimony, and in cases connected with renal disorder I observed relief, mainly owing, as it seemed, to increased activity of the skin and intestinal glands.

Hypochondriasis—Mental Depression.—In these conditions antimony has been commended, but can only act favourably through the strongly stimulating effect of emetic doses, and modern practice seldom resorts to this treatment.

Epilepsy.—Like so many other medicines, antimony has been applied in the treatment of epilepsy, especially, but not only, in plethoric subjects (Cheyne, Bell, etc., Glasgow Med. Journ., Oct., 1857, Ranking, 1858).

Delirium Tremens.—Though antimony is seldom now prescribed for this condition, the good results obtained from it, by Dr. Peddie especially, require some notice. He speaks of uniform success in upwards of eighty cases, treated mainly by ½ to ¼-gr. doses, given every two hours until improvement set in; emetic action was not marked, but occurred to some extent with the early doses: secretion from the kidneys and the skin was increased, but he attributed the benefit rather to a sedative effect on the nervous system and the lowering of vascular excitement (Edin. Month. Journ., 1854). In America and in Germany, larger doses have been successfully used—Schroff, for instance, giving 4 to 6 gr. daily, and others the same dose every hour. The practice, however, is dangerous, because in this malady the circulation fails so readily, and Dr. Anstie has pointed out that antimonial treatment, though certainly successful in some cases, has ended unfortunately in others (Reynolds' System, ii., p. 92). I have found its moderate use valuable in young robust men, especially in the first attack, and even when much gastric derangement was present: it is not so suitable for old or debauched subjects.

Chorea.—The emetic action of antimony has been utilized for the relief of chorea, and the influence of the remedy has been explained as reflected through the vagus nerve to its central origin in the medulla, inducing sedative effects in that part (Ringer). Boulay and others have recorded successful cases

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from the use of nauseating doses (Bull. de Thérap., v., 52–4, Lond. Med. Rev., 1861), and Dr. West recommended it, but I cannot consider it a desirable treatment, nor is the evidence in its favour very strong. Comparing it with arsenical treatment in twelve cases in Parisian hospitals, only half the number were reported cured by antimony, and some of these lasted long enough at least for natural recovery (fifty-eight days); whereas of eleven cases treated by arsenic all got well (M. Long). Of course, in comparisons of this kind we must make some allowance for the tendency of chorea to recover under judicious management, independently of medicine, but the general evidence in favour of arsenic much outweighs that in favour of antimony.

Asthma.—Some forms, especially of dry spasmodic asthma, are much relieved by repeated small doses. Dr. Ringer has noted their value in attacks of wheezing and orthopnœa of asthmatic character to which some children are subject after exposure to cold, and which sometimes follow measles. In such cases he recommends one teaspoonful every quarter-hour of a solution containing only 1 gr. in ½ pint of water: even this amount may cause vomiting, though that effect is not necessary for relief. Dr. Koch has remarked that the remedy is most useful when the attacks are brought on by peripheral irritation (cold, etc.), rather than by emotional causes; and he speaks highly of a combination with arsenic acid—the arseniate of antimony—which he administers in the form of vapour from a cigarette (Practitioner, vol. iv.).

Emphysema.—Dr. Koch has found the same salt act well as a nervine and muscular tonic in emphysema; and, according to my experience, it certainly deserves further trial.

CONTRA-INDICATIONS.—General feebleness, and especially feebleness of the circulation or of the digestion, would usually prevent the giving of antimony; hence it should rarely be prescribed in *infancy* or in *advanced life*. To children it has proved specially dangerous sometimes, by inducing a condition of collapse without much warning, but a remedy so valuable in their acute inflammatory affections, should not be wholly withheld: in old persons it is more liable to derange the

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stomach. Before emetic doses are ordered for a patient, inquiry should be made, if possible, as to the existence of hernia, aneurism, or other arterial or cardiac disease, cerebral congestion, uterine displacements, or pregnancy: such conditions should contra-indicate the production of vomiting.

PREPARATIONS AND DOSE.—*Antimonium sulphuratum:* dose, 1 to 5 gr. as an *alterative;* 10 to 20 gr. as an *emetic.* Is seldom prescribed unless in the compound calomel pill (Plummer's). *Antimonium tartaratum:* often given dissolved in plain water, but the pharmacopœial solution of it is a "*vinum antimoniale*" containing 2 gr. to the ounce. This is convenient for giving small doses of the drug, especially in febrile conditions, but is not very suitable when larger quantities for depressant effects are required. Dose: *as diaphoretic and expectorant,* $\frac{1}{16}$ to $\frac{1}{8}$ gr. of the powder, or 15 to 40 min. of the wine every one to three hours; for children, smaller doses (*v.* pp. 375–9); *as vascular depressant or sedative,* $\frac{1}{16}$ to 1 gr.; *as an emetic,* 1 to 2 gr. and upwards. *Unguentum antimonii tartarati* (contains 1 part of tartarated antimony to 4 of simple ointment). *Antimonii oxidum:* dose, 1 to 4 gr. *Pulvis antimonialis,* the officinal substitute for James's powder: dose, 3 to 10 gr.—the latter dose causes vomiting. *Liquor antimonii chloridi:* used only as a caustic. *Antimonium nigrum:* not used except in the preparation of antimonium sulphuratum, and liquor antimonii chloridi.

ADULTERATIONS.—The powdered tartar emetic may contain free tartrate of potash, lime, copper, iron, or arsenic.

ARGENTUM—SILVER, Ag, = 108.

This metal occurs pure, but more often in alloy, as with lead (galena), or combined with sulphur (argentite), chlorine (horn silver), and with iodine, bromine, etc.

Refined silver is placed in the Pharmacopœia as a source of the nitrate, but is otherwise used only in the form of silver-

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leaf as a coating for pills: its officinal salts are the nitrate and the oxide.

ARGENTI NITRAS—NITRATE OF SILVER, $AgNO_3$, = 170.

Prepared by crystallization from a solution of pure silver in dilute nitric acid: when fused and solidified in moulds, it constitutes the small pencils known as "lunar caustic."

CHARACTERS AND TESTS.—The crystals are tabular and colourless, and form a neutral solution with distilled water: sp. gr. 4·3. They are soluble in four parts of rectified spirit; when pure they do not blacken on mere exposure to light, but do so, and readily decompose, on continued contact with any organic substance.

An aqueous solution of the nitrate is precipitated by any soluble chloride, a characteristic curdy-white chloride of silver being formed, which becomes dark on exposure to the air: it is soluble in ammonia, insoluble in nitric acid. A black sulphide of silver is precipitated from a solution of the nitrate by passing through it sulphuretted hydrogen.

ARGENTI OXIDUM—OXIDE OF SILVER, Ag_2O, = 232.

PREPARATION.—By precipitation from a solution of the nitrate by means of lime-water.

CHARACTERS AND TESTS.—Occurs as an olive-brown powder: sp. gr. 7·2. It is reduced to the metallic state by a red heat, is soluble in ammonia and in nitric acid, but slightly soluble in water, to which it gives a metallic taste and an alkaline reaction.

Chloride of Silver, AgCl (not officinal).—Readily obtained by decomposing any silver salt with hydrochloric acid, when it precipitates as a white caseous powder (horn silver): it darkens on exposure, and is soluble only in ammonia and in hydrochloric acid.

The Ammonio-chloride (not officinal) is an unstable salt soluble in water. *The Chloro-albuminate*, the *iodide*, and the *double iodide* of silver and potash are soluble salts that do not coagulate

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albumen. The *hyposulphite* of soda and silver is astringent and less irritant than the nitrate; the *cyanide* is said to be more readily absorbed.

ABSORPTION AND ELIMINATION.—Nitrate of silver, when taken into the stomach, forms with mucus and epithelium a thin pellicle, which, to some extent, hinders absorption. The chemical change which all silver salts undergo, more or less, when in contact with the gastric secretions, results in the formation of a double chloride of silver and sodium, and although *ordinary* chloride of silver is insoluble in water, this *double* chloride is readily dissolved by the gastric fluids; its combination with peptones is also soluble (Bogolowsky, Virchow's Archiv, xlvi., 1869, and others). As chloride and albuminate it probably passes into the blood, and circulates with it, being retained in solution by the alkaline serum (Rouget), though Frommann thought that it separated in the molecular form (Archiv f. Path. Anat., 1859). Dragendorff considers that the chemical changes occur chiefly in the duodenum, and that the gastric juice being here neutralized by the bile, silver sulphide is ultimately formed: certainly, of unabsorbed silver compounds, the greater part passes off by the bowel as sulphuret, colouring grey or black the mucous membrane and the fæces. More of the salt will be absorbed if given in solution in distilled water on an empty stomach, than when given in pill in the ordinary manner. Riemer has shown that in pills (? bread) four-fifths of the silver nitrate is decomposed even before administration (Archiv der Heilk., xvi., 1875). The same observer also sought to prove that molecules of silver pass in a mechanical manner through the intestinal walls, but Fragstein could detect no absorption of freshly-precipitated silver-chloride introduced into the intestine of frogs (Berlin. Klin. Woch., 1877). Orfila and Heller failed to find traces of silver in the blood after its administration; but Orfila, and Panizza found it in the urine (Husemann), and Cloez isolated a globule of the metal from the collected urine of several patients at the Salpétrière. It has been found also in the liver and the bile, and some is eliminated by the cutaneous glands. Rozsahezzi found it in the intestinal contents, after its hypodermic injection (Archiv Klebs, 1878).

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The most important practical point is, that elimination of silver salts by any channel occurs but *slowly*, so that if they are taken continuously for a long time, the reduced metal becomes deposited in the tissues, giving them a dark-grey coloration, known as "*argyria*." The gums show the earliest indication of this condition by a bluish line (which is darker than that produced by lead), and parts exposed to light show the colour more than others—thus the lunula of the nail (Falck), the eyes, the face and hands are affected early; the deposit is in the true skin (corium). Neumann has recently examined minutely a portion of the skin of a man who had partial argyria from frequent applications of nitrate to reduce large papillæ on his tongue: dark granules of the metal were found in the upper part of the cutis, in the wall of the sweat-gland, in the connective tissue of hair-follicles, in sarcolemma, neurilemma, and the middle coat of vessels; none were deposited in the epidermis, the mucous layer, or the epithelial lining of hair-follicles or sweat-glands (Med. Record, 1877). That the colouring is partly due to the influence of light is shown by cases in which the viscera were seen to darken after exposure (Huet, Frommann, Fragstein), but the more active circulation of exposed parts is another factor in their coloration.

If the drug be stopped on the earliest appearance of affection of the gums, the general discoloration is not likely to occur. This was shown in the case of a woman who took nitrate of silver for two months—at first ¼ gr., and later 2 gr. daily—swelling and redness of gums, with a purple line at the edges, appeared, and there was much tenderness of mouth with metallic odour of breath; but on ceasing the medicine, these symptoms subsided (Bull. de Thérap., v., 1871, p. 86). In other cases when large quantities have been taken, every part of the body has been affected. Van Geuns reports that a youth took about ½ gr. of the nitrate daily (with occasional intervals), from his fourteenth to his nineteenth year, none afterwards: he died of phthisis at the age of thirty-five, and not only was the skin coloured, but also the cerebral and spinal membranes, the laryngeal and bronchial membranes, the peritoneum, the papillæ, and malpighian bodies of the kidney, the marrow, and the bones; the nervous, the hepatic, and other

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parts of the renal tissue were reported normal. Heynsius concluded on analysis that the dark granules were not chloride of silver (for ammonia did not affect them), nor oxide, but minutely divided particles of the reduced metal, and this conclusion is now generally accepted (Abstract, Dub. Quart. Journ., Aug., 1858).

Charcot has recorded the presence of silver round the renal glomeruli and in the malpighian pyramids, and Liouville has made a similar observation as to the kidneys, and also as to the choroid plexus of a patient who had taken 110 gr. in the course of nine months, three years before his death. Virchow recorded renal argyria after absorption from connective tissue. Several cases are quoted by Stillé, by Sieveking, by Riemer, and others (Schmidt's Jahrb., ii., 1875, p. 295): many of them seem to have died of phthisis several years after the administration.

Arygria may even follow *local* applications of nitrate, as in the case of a girl whose throat was repeatedly cauterized—perhaps fifty times in the course of twelve months;—she is said to have swallowed the products (Gaz. de Paris, xxviii., 1874). It has occurred also after tracheotomy, the wound having been pencilled "for a long time" (Dict. Encyclop., v., vi.), and in a woman after the continued use of a nitrate pomade for dying the hair.

It is important to ascertain, if possible, what quantity of the drug is liable to produce coloration, and the time during which its use may be safely continued. The actual amount deposited is certainly very small: Versmann found only 0·047 per cent. in the liver in a well-marked case, but Krahmer estimated that there must be the residue of at least 1 oz. of the salt to cause discoloration: from 3 to 5 oz. are mentioned as the quantities taken in several instances, but judging from Liouville's case, it is probable that less than 1 oz. might suffice. Six weeks has been named as a safe limit of time for the continued administration of the drug, and I should think it almost impossible for any ordinary dose to produce bad results within that period.

The sulphide was the salt used in the first authentic recorded case of coloration (Weigel): the iodide is said to be free from this risk, and no case has been traced to it, but

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Husemann considers this as accidental: the double iodide of silver and potash is also regarded as less liable to be deposited (Delioux).

PHYSIOLOGICAL ACTION.—*External*—If moistened nitrate of silver be applied lightly to the skin, it combines with albuminous material, and leaves a white stain, which soon darkens on exposure to air or light, because of its reduction to metallic silver; the darkened epidermis peels off in a few days' time. Strong applications, such as the moistened stick, or solutions of 1 to 2 dr. in the ounce, cause more or less severe burning pain, and in delicate skins, vesication. On mucous membranes, or moist denuded surfaces, a whitish layer is formed by combination with chlorides and albuminous secretion: this layer soon becomes grey and then dark, and when it peels off may leave the part tender. Applied to a suppurating surface, the solid nitrate combines with the purulent secretions to form a greyish layer, stimulates the healing process, and causes some burning pain and redness near the part: when the superficial eschar falls, as it does in twenty-four to forty-eight hours, fresh and healthy granulations are usually found on the wound. The action cannot extend deeply because of the pellicle which is formed, and the so-called "caustic" effect of nitrate of silver must be distinguished from that of destructive agents, such as potash or acids, for it is produced by coagulating and hardening organic tissues, rather than by destroying them. The affinity of the salt for albumen, and its forming with it an insoluble compound, explain most of the local effects of the nitrate.[1]

A solution of about 20 gr. per ounce brushed over a moderately inflamed part not only discolours it, but reduces its size, controlling inflammation, and constringing the blood-vessels. The conjunctiva has sometimes been discoloured by continuous use (to it) of medicinal drops, and in this and other very sensitive parts, such as the schneiderian, buccal, or urethral membranes, much pain, irritation, and increased secretion follow the use

[1] The chemical formula of the silver-albumen compound seems to vary under different conditions. Lassaigne gives 84·5 per cent. albumen, 15·5 of nitric oxide of silver; Mulder, 16 of the latter in one experiment, 8·9 in another; Krahmer, nearly 12 per cent. Delioux pointed out that the affinity of the nitrate for albumen is greater than it is for chlorine (Husemann).

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of strong solutions. Weak solutions (1 to 3 gr. in 1 oz.) have an astringent and slightly stimulant action, and do not cause pain except to a delicate membrane like the conjunctiva. Silver solutions possess, also, antiseptic power, in degree somewhat proportionate to their strength, and dependent in part, though not wholly, on coagulation of albumen.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Small doses of the oxide ($\frac{1}{4}$ to $\frac{1}{2}$ gr.), and still smaller ones of the nitrate of silver ($\frac{1}{8}$ gr.), are usually well borne by the stomach; but the latter salt produces a metallic, bitter taste in the mouth, and, unless well diluted, causes burning sensations in the fauces. In $\frac{1}{2}$ to 1-gr. doses it is apt to induce nausea or vomiting, pain, and diarrhœa; headache and vertigo are usual accompaniments. The continued use of smaller medicinal doses impairs the appetite, and may induce intestinal catarrh and hæmorrhage. Any amount over 4 or 5 gr. would be usually rejected by vomiting, otherwise it would excite inflammation. After death from toxic doses, the gastro-intestinal membrane has been found soft, eroded, or covered with grey patches. In chronic cases the muscular and mucous coats become hardened and thickened.

Nervous System.—The main point determined by modern investigation into the action of silver compounds is their special effect upon the nervous system. The best experiments have been made upon animals by hypodermic injection of hyposulphites and albuminates of silver, which do not coagulate albumen. Charcot and Ball reported, as usual results of such injection, paraplegia and paresis of pulmonary nerves, probably reflex in character, leading to profuse bronchial secretion and asphyxia (Gaz. Méd., 1864). Rouget found that in mammalia, small doses caused excitement somewhat like strychnia; toxic doses induced convulsion and asphyxia. Batrachians got convulsions or tetanic spasm with suspension of voluntary movement, of reflex action, and of respiration, whilst circulation continued; weakness, torpor, somnolence, and paralysis also occurred in various degrees (Archives de Physiol., 1873). Professor Curci, experimenting on animals with hypodermic injections of hyposulphite of silver, reports that at first they stimulate sensory nerves, and

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through them the posterior columns of the spinal cord, so that sensibility to impressions and reflex excitability are increased—this condition extends more or less to the motor nerve-tracts, muscular irritability is heightened, and tetanus may be produced: afterwards follows a secondary effect of paresis of sensory nerve-centres, and of those connected with respiration; ultimately reflex action is arrested, and respiration and circulation cease. We may accept these facts without assenting to the conclusions drawn by Professor Curci from them, viz., that since silver compounds ultimately paralyse, they cannot be of service in paralysis, myelitis, etc., but are only indicated in spasmodic disorders, especially such as affect respiration (Med. Record, 1877).

Bogolowsky, in his experiments, sometimes found the spinal cord so far affected that the bladder became greatly distended.

An exceptional illustration of the nerve-effects of the drug on man, may be found in the case of a man accustomed for twelve months to dye his hair and beard with a strong solution, and who suffered general weakness, confusion of thought, loss of memory, tinnitus aurium, and defective sight, which symptoms ceased soon after stopping the dye (Bresgen, Schmidt's Jahrb., 1874, Bd. clxii.). Within my own experience I have known men suffering from the same cause, with giddiness, vertigo, and marked nerve-depression, amounting almost to melancholia, and recovering quickly after ceasing the application. Convulsions occur in children after toxic doses of the nitrate, but they are probably reflex—*i.e.*, dependent upon gastric irritation (B. M. J., i., 1871).

Circulatory System.—After intravenous injections of silver salts, the blood has been found dark, pitchy, impaired as to coagulating power, and containing small crystals, and "whitish granulations," which were supposed to be chloride of silver (Rabuteau), but are more probably hæmatin and protein (Rouget). Ecchymoses have occurred, and, together with the asphyxia and increased bronchial secretion, have been attributed to the altered chemical condition of blood (Krahmer, Monograph, 1845), but such alteration is not produced (in acute form) by silver administered in any other way than by direct injection into the blood. Even toxic doses given

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in other ways do not alter that fluid beyond some lessened coloration of the corpuscles and increase of fibrin (Bogolowsky, loc. cit., Rouget); the spectrum remains normal. But after the continuous use of full doses of albuminate or phosphate of silver, the blood-condition certainly becomes impaired; the fluid is found to be thinner and darker, and it tends to stagnate in, and transude through, the vessels, whilst the corpuscles part with hæmo-globulin, and become pale, transparent, and angular or oval, with projections: according to Bogolowsky, they do not contain silver, as sometimes asserted.

Sudden arrest of the heart's action, as well as asphyxia with profuse bronchial secretion, were symptoms noted by Charcot and Ball after injections of silver nitrate into the veins of animals. Rabuteau, arguing from the same results, considered the drug to be a "cardiac poison," but it is clear that when thus injected directly into the circulation, the production of thrombosis or embolism may complicate and obscure the special effects of any substance. Rouget found that after hypodermic injection of toxic doses in the lower animals, the heart continued beating after respiration had ceased—*i.e.*, it was not "poisoned;" nor is there any clinical evidence of the salt depressing the circulation, unless in a secondary manner during irritant or chronic poisoning.

Respiratory System.—Orfila first described asphyxia as a result of injecting silver nitrate into the veins, and after death he found partial consolidation of the lungs, and excessive secretion in the bronchial tubes (Toxicology). Several observers have corroborated these results, and it has been a question whether they are mainly mechanical from thrombosis, etc., or reflex effects of lung-irritation (Charcot), or dependent upon direct irritation and paresis of the respiratory centre in the bulb, and of the neighbouring vaso-motor centre. The recent observations of Rouget point to the latter conclusion. He found that in most animals urgent dyspnœa occurred, and, post-mortem, the lungs proved to be healthy in texture, but much contracted in volume—the muscular tissue of the bronchi being in a state of spasm similar to that of asthma. In adult specimens of only one order of animals (carnivora) did he find the excessive secretion described by Orfila, and he considered that only in these were the vaso-motor centres affected. That the main effect is

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exerted on the central rather than on peripheral nerve-elements he further supported by showing that nerves and muscles retained electric excitability after death. Still more recent observations by Rozsahezzi on rabbits show that in chronic poisoning by silver there is constantly hyperæmia of laryngeal and tracheal membranes, also of the lungs, and in these organs often œdema was found, with congestion, ecchymoses, effusions, cheesy masses, and sometimes a condition resembling phthisis (Archiv, Klebs, Aug., 1878).

Nutrition.—Krahmer concluded from observations on himself, that the presence of silver in the system lessened oxygenation and the excretion of urea, of uric acid, and of the watery constituents of urine; the non-nitrogenous elements were, however, increased, and the sp. gr. rendered higher. If the administration of silver salts be continued beyond a certain point, cachexia sets in, appetite and digestion are impaired, catarrh and effusions take place, the temperature is lowered, and the action of the heart and lungs weakened. The general debility and emaciation are mainly dependent upon gastric irritation, but the drug seems to exert a special "alterative effect" on tissue-change. Dr. H. Wood classes it with "mineral astringents," Dr. Bartholow with "agents increasing waste," but I think it better placed amongst those that "moderate or retard nutritive processes" (Rabuteau). The recent observations of Rozsahezzi show a very marked diminution of tissue-change and of weight, under the continued influence of small doses of nitrate. This occurred even whilst the animal was taking a good amount of food, and when no increased excretion could account for the loss; he thinks it indirect from impaired blood and muscle-condition.

He finds (as opposed to Bogolowsky) that small doses cause a rise in temperature, but agrees with Falck that large ones lower it.

When death has followed the long-continued use of the drug, the epithelial structures, and the solid tissues generally—the liver, heart, muscles, kidneys, etc.—have been found in a state of "cloudy swelling" and fatty degeneration, and the metal has been detected in most parts of the body.

Fatal Dose (Acute Poisoning).—This varies with the

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gastric condition, period of vomiting, and of treatment, etc.: 30 gr. of nitrate have caused death in one case, whilst 1 oz. has failed to do so in another (that of Poumarède). Large doses have been neutralized by excess of natural mucus, or of albuminous food.

SYNERGISTS.—As regards local effects, the nitrate is allied with irritants and caustics, such as iodine and arsenic. In its general action, especially in therapeutical doses, a resemblance may also be found with these medicines as well as with compounds of chlorine, bromine, and salts of bismuth, and in a less degree, of zinc. Some analogy with strychnia has been traced (Charcot).

ANTAGONISTS AND INCOMPATIBLES.—Sulphuric, hydrochloric, and tartaric acids and their compounds are chemically incompatible: also alkalies and their carbonates, astringent infusions, and lime-water; also creosote (*v.* p. 415). All soluble chlorides and cyanides are incompatible, since they precipitate an insoluble chloride of silver; most natural waters do so because they contain common salt: this salt is the best antidote to poisonous doses of the drug, and should be given freely so as to cause emesis as well as to neutralize the poison.

THERAPEUTICAL ACTION.—*External.*—Nitrate of silver may be applied either (1) as a caustic, (2) astringent and alterative, (3) counter-irritant, or (4) as a direct irritant.

1. *Caustic.*—Lupus.—In cases of tubercular and ulcerating lupus the "lunar caustic" is sometimes suitable, and in the hands of Hebra, Neumann, and others, has given good results. No ordinary application or simple pencilling will be of any service, for it will not extend deeply enough, but a well-pointed "stick" should be firmly pressed into the soft tissue, in various directions and until hard tissue is met with: this is an extremely painful process, and in my experience can seldom be thoroughly done except under chloroform. As a rule, I prefer the nitrates of mercury or of zinc, but silver has the advantage sometimes where the face is affected, because its action can be so precisely limited to the diseased part, and does not cause so marked a cicatrix. Dr. Piffard recommends fine needles to be coated with

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the caustic and passed into the growth, finding this to be less painful than Hebra's method. Soothing applications, such as poultices and lead lotions, should be made after the cauterization, which may require repetition once or even twice weekly for some time. M. Claude specially recommends the double iodide of silver and potash (internally) in lupus and skin-disorders.

Warty Growths—Corns, etc.—The use of the stick-nitrate for destruction of these growths is familiar in practice, and is safe and painless, though not very quick in its results, for only a thin layer can be acted upon at each application: the part should be thoroughly softened and pared before the remedy is applied.

Carcinoma.—For the removal of cancerous growths, Thiersch has employed injections into their substance of solutions of 1 part of nitrate in 2,000 or 3,000 parts of water; this is followed by a similar injection of dilute chloride of sodium (1 in 1,000), and is said to cause quick disintegration and wasting of the morbid tissue. There is some independent confirmation of his results, but usually suppuration and sloughing have occurred—an effect which Thiersch did not intend (Archives Gén., Jan., 1867). I am not aware that the method has been extensively tried.

Poisoned and Dissection Wounds.—In such wounds a liquid and penetrating caustic, like nitric acid or potash, is more thorough in its effects, but nitrate of silver, being portable and at hand, has often been employed with good result; its antiseptic power is a recommendation. Mr. Youatt reports that he was bitten several times by rabid animals, and after a free use of this remedy had no ill results; but the degree of security given must vary with the thoroughness and time of the application.

Variolous and other Pustules.—Lunar caustic has proved useful sometimes in aborting purulent formations. The absence of pitting after small-pox being dependent upon the small size and limited inflammation of the pustules, Velpeau and others have endeavoured to secure such a result by puncturing the vesicle on the third or fourth day, and touching the interior with a fine point of the nitrate; and if well carried out this plan has often succeeded. It is painful, tedious, and not free from danger, but the plan devised by Dr. F. Bowen is an

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improvement upon it, and is much more feasible: the vesicle is to be punctured with a fine needle dipped in a solution of the salt (20 gr. to 1 oz.); a nurse can do this quite well. In one case all the parts thus treated recovered perfectly, whilst the vesicles that were untouched left deep scars (quoted by Ringer). Mr. Higginbottom recommends painting of the face with the same strong solution that he used for erysipelas (80 gr. to ½ oz.), but this is too painful for ordinary use.

Molluscum Contagiosum.—The rounded, white, firm tumours of this malady are efficiently treated by evacuating their contents and applying nitrate of silver to the interior, as above described for variola.

Chancre.—Opinions have differed as to the possibility of preventing venereal infection by applications of nitrate to the sore soon after its appearance; authorities in favour of such practice are to be found amongst earlier writers, but modern opinion is decidedly against it. Hunter, Ricord, and Acton (writing in 1846) agree in stating that if the commencing chancre, the vesicle, or pustule be thoroughly cauterized within three to five days of its origin the cure is rapid, and systemic infection very rare; but they agree also that if the sore be indurated no effect is produced, so that some of the cases they relied upon were probably "soft and non-infecting chancre:" on the other hand, Diday, Langston Parker, and others, have thus destroyed chancres within a few hours of their appearance, and yet an indurated sore and secondary symptoms have followed. We must conclude that cauterization of a true Hunterian chancre at any stage will not prevent its development or the occurrence of secondary symptoms.

Early cauterization of soft chancres will however, sometimes cause rapid healing, and is a good treatment for sloughing or rapid spreading; but it is very painful, and the sore will usually heal under simple treatment. In syphilitic ulcers of the leg I have seen solid gelatinous fungating growths, which are well treated locally by pushing in a point of caustic and breaking them down freely with it, as already described under lupus. For syphilitic cracks, fissures, and ulcers on tongue and cheeks, the solid nitrate applied daily is very useful.

Granulations.—A minor degree of the caustic action of

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nitrate of silver will repress exuberant granulations in wounds; they should be pencilled every day or every second day.

2. *Astringent and Alterative.*—By the latter term we mean to express the modifying effect exerted on tissues, and especially on mucous membranes, whereby an unhealthy condition, usually inflammatory in its nature, is subdued, and healthy action is set up in its place. Trousseau taught that this effect is due to the new agent (nitrate of silver) causing a more powerful inflammation than the original one which it displaces, afterwards itself subsiding; and this idea he developed at length under the term, "médication irritante substitutive" (Mat. Méd., i., 537), but we cannot prove the occurrence of any substitutive inflammation of this kind. We refer the effects of the remedy partly to its known physical properties of constricting vessels, of coagulating and disinfecting secretion, and of forming an adherent protective membrane; also, in certain conditions, *e.g.*, in ulceration, the vessels immediately acted on being constringed, those in the neighbourhood receive a better supply of blood, and the processes of repair are quickened;—the remedial power which is special to the drug, which distinguishes it from other astringents, and by which it modifies nutritive processes, we can only express by the term alterative.

In many forms of disorder accompanied by *discharge*, whether hæmorrhagic, mucous, serous, or purulent, the nitrate, either solid or in injection or spray, is very valuable. (Delioux recommends the hyposulphite of soda and silver as equally astringent and less irritant.)

Hæmorrhage.—In cases of continued oozing from small points in the skin or mucous membranes, such as occurs after leech-bites, a finely-pointed stick of nitrate firmly pressed on the part is a good astringent. In bleeding from the mucous membrane of the bladder, such as accompanies vesical tumour, injections should be made, beginning with weak solutions, and increasing the strength by degrees if necessary. Mr. Christopher Heath speaks highly of this plan, and I have seen several instances of its successful use in his hands.

Chronic Cystitis.—After washing out the bladder, a solution containing 1 to 2 gr. in 1 oz. of distilled water should be injected and allowed to remain for some minutes, or until

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micturition occurs; this lessens the muco-purulent ropy secretion from the vesical membrane: Mr. Reeves has used with success 20 gr. in 1 oz. (Lancet, i., 1853).

Gonorrhœa.—At the commencement an injection containing 30 or even 60 gr. to the ounce has sometimes succeeded in aborting the malady, but it causes severe pain, and may lead to serious inflammation. In the female, a similar solution applied thoroughly, per speculum, to the vagina has given better results, and offers less risk on account of the anatomical conditions; but, as a rule, the frequent use of a weaker solution is more advisable. I recommend, so soon as the acute inflammatory stage begins to subside, an injection containing ½ to 1 gr. in the ounce every three or four hours; or sometimes a strength of only 1 gr. in 8 oz., to be injected every half-hour for the first eight hours, and afterwards every four hours until cure is effected, which should be in twenty-four to forty-eight hours. I have had most excellent results in many obstinate cases from this method; it should not be wholly omitted at the end of forty-eight hours, but used once, or twice, or if the discharge continues, a little oftener for the following two or three days.

Balanitis.—Gonorrhœal inflammation of the glans penis is effectually treated by the frequent use of a weak lotion (1 gr. in 1 oz.) in addition to light pencilling with the solid stick.

Spermatorrhœa.—The treatment by local application of a strong solution to the prostatic urethra in the neighbourhood of the openings of the seminal ducts was strongly commended by Lallemand, but his statements are exaggerated; it is useful sometimes, but should not be employed without due consideration: I have seen serious consequences follow it.

Leucorrhœa.—Injections of silver nitrate have been found effectual in the vaginal form of this disorder, the strength of application being proportioned to the duration of the malady: a drawback to its use is the staining of linen. (There are several varieties of leucorrhœa, and each must be treated on its own merits, as some will require internal remedies as well as injections—the checking of discharge by this or other astringents is only one part of successful treatment.)

In *uterine* leucorrhœa the discharge is glairy and stiffens the

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linen, and is accompanied with distinct suffering. It is usually connected with cervicitis or endometritis, and in chronic stages, especially when the os uteri is patulous, solutions, and even the solid nitrate, have been passed into the uterine cavity with good result (Dr. Henry Bennet): this, however, has led to some abuse of the remedy, and I have seen very painful symptoms connected with induration of the cervix and narrowing of the canal as a consequence of too prolonged a course of cauterization.

Granular Erosion of Cervix (formerly known as *ulceration*).—The nitrate has been much used in this condition, but the solid salt can exercise only a limited influence. In chronic cases, where the part is enlarged, and the epithelium so long absent that the bared villi resemble granulations, I have found benefit from recently-prepared iodide of silver, as recommended by Dr. Henry Wright.[1] All mechanical causes of erosion of cervix, such as impacted fæces, must be considered, and if present, treated at the same time.

Real *ulceration* of the cervix, as distinguished from erosion, is usually connected with syphilis, struma, or malignant disease, and although the nitrate has been often used for it, more potent remedies, such as the acid nitrate of mercury, are really required.

Ulceration.—When an ordinary ulcerated surface is discharging freely, a lotion of moderate strength is usually more suitable than the solid nitrate, because it does not involve confinement of discharge under a limiting membrane (though, indeed, such membrane may be punctured if necessary).

The best use of the solid stick is made in indolent ulcers with pale small granulations, and but slight discharge. The remedy should be lightly applied over the central parts, avoiding the new tissue at the margins, and under this stimulus, and the protection of the film which is formed, healing will be much quickened. The brittle stick nitrate is superior to the prepared points of "lunar caustic," for it is more soluble. Cuthill insists on the importance of stimulating an ulcer rather by dots and

[1] To a little of the strong silver solution (3j. in 3j.) a few drops of tinct. iod. are added, and the iodide of silver precipitates at once in white flakes, which should be quickly applied—through the speculum (Uterine Disorders, p. 260).

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lines of silver nitrate than by coating its whole surface, better exit for discharge being thus given (Edin. Med. Journ., 1877).

Purulent Ophthalmia.—In the ophthalmia of new-born children, and also in the epidemic and the gonorrhœal forms of the disorder, solutions of nitrate are extremely valuable, though they often cause severe pain for a time. The lids should be separated and the eye cleansed by a stream of tepid water, and in acute, not very severe cases, a few drops of a solution (2 to 5 gr. in 1 oz.) should be instilled—in very severe cases with chemosis, a strength of 20 or 30 gr. in the ounce may be employed once or twice daily, but should be followed by a syringeful of plain water, or of weak salt-solution, in order to neutralize any excess of nitrate (*v.* p. 414). In chronic cases, especially when scrofulous in character, with thickened conjunctiva, photophobia, lachrymation, etc., the solid stick may be lightly used to the lids with advantage; but in all cases the liability to discoloration must be remembered, and the remedy not be used too often nor too long; when ulceration is present, or the membrane not entire, other remedies should be preferred.

Otorrhœa, with perforation of tympanum and with tendency to formation of polypus, is best treated by touching the tympanic mucosa with a concentrated solution of the nitrate: the discharge should be daily removed by ordinary antiseptic lotion.

Ozæna—Coryza.—In chronic nasal discharges, if the bones be not seriously affected, and in ordinary coryza, benefit may be derived from injections of nitrate of silver (2 to 5 gr. in 1 oz.). In the former condition, a cleansing and disinfectant nasal douche should first be used, and afterwards the astringent should be injected from behind forwards by means of a curved tube passed to the back of the fauces, and connected with a rubber ball.

Nitrate of silver in various forms is an important agent in the treatment of diseases of the *throat and air passages*, but its strong and caustic action is invoked much less frequently now than formerly; we require rather the astringent or alterative action to relieve congested, or brace relaxed parts. Dawosky concludes, after extensive experience, that whenever local applications are required for congested mucous membranes,

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nitrate of silver gives the best results; besides its chemical influence, it stimulates the congested vessels to contract and get rid of their excess of blood. For congested conditions of the fauces with adherent secretion and patches of redness and swelling, he recommends a strength of 1 part in 8 (Med. Record, March, 1878), but I think it better to *begin* at least with half this proportion.

Tonsillitis.—In the early stage of this inflammation—it must be at least before suppuration has set in—a strong solution (30 to 60 gr. to 1 oz.) applied once in twenty-four hours will sometimes abort further progress. Judgment is required to determine the suitability of cases for this treatment, for if the inflammation be advanced and active, irritant applications tend to increase it. In sloughing ulceration about the fauces, strong nitrate solutions are sometimes serviceable, and are better than the solid caustic; but more active disinfectants, such as iodine or carbolic acid, are still better.

Diphtheria.—In diphtheritic inflammation with membranous deposit, I cannot recommend the strong nitrate; if the part be irritated it is more liable to inflame, and if the membrane be roughly detached the absorbents more readily receive morbid material, so that although this remedy was at one time commended, I am satisfied that the use of a solvent or disinfectant spray is more serviceable, and is far more thoroughly and easily effected. Strong nitrate of silver is not a suitable local remedy for membranous croup (laryngeal diphtheria), or *acute* congestion of the larynx. I have seen almost fatal suffocative spasm of the vocal cords induced by the application of the solid nitrate in the latter condition. Guillon, however, states that the insufflation of finely-powdered nitrate may be very useful (Med. Record, 1877); sometimes a weak spray (1 gr. to 1 oz.) has been of service.

Œdema Glottidis—Chronic Congestion.—This severe form of œdema is sometimes quite controlled by strong silver-solutions, which may obviate the necessity for scarification or more serious procedures. In *chronic* laryngeal and faucial congestion, a curved brush carrying a solution of 20 to 30 gr. to the ounce may be applied with the help of a mirror to the exact part affected, and with very good result. Dr.

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Horace Green and Dr. Hughes Bennett were early advocates of this method of treatment. Many surgeons, however, now prefer solutions of copper, zinc, or iron, as causing less irritation, and less risk of after-contraction, than the silver salt. A *weak* spray is of very little service in these conditions, and the use of the brush has largely superseded the method of insufflation which was approved by Trousseau. He used 3 gr. of the nitrate mixed in fine powder with 60 gr. of sugar of milk, and this was blown into the patient's mouth during a deep inspiration, by which some of it was carried into the larynx.

Laryngeal Phthisis.—The solution is, according to my own experience, of much service in the early stage of this disease, and has been recommended by the late Hughes Bennett, Marcet, and Sawyer, but objected to by L. Thomas (B. M. J., i., 1878). It has been advised in malignant disease.

Relaxed Throat, etc.—It is, however, in chronic relaxed conditions of the fauces and pharynx, with dysphagia and constant discomfort, aching in the throat, cough, and hawking of phlegm, that the remedy gives most relief. There is no acute inflammation present, and the affected parts are either pale with prominent follicles, or swollen and of purplish colour, with more or less viscid, yellowish secretion. In "clergyman's sore throat," the follicles of the pharynx mainly are affected, and in all these cases a solution of 20 gr. to the ounce, with glycerine, should be applied once daily, or on alternate days, whilst tannin, borax, etc., are used in the intervals.

In *aphonia* connected with local debility and relaxation, silver applications relieve by their astringent tonic action, and in hysterical aphonia the irritation excited is often sufficient to restore the voice.

Relief may also be given to obstinate *coughs* arising from relaxed faucial conditions, and not amenable to internal remedies, by a solution containing about 5 to 10 gr. in the ounce, applied once or twice daily.

Chronic Bronchitis.—In cases accompanied with profuse muco-purulent discharge, I have often proved the efficacy of a spray containing nitrate of silver. I use only weak solutions—from 1 to 4 gr. in the ounce—and find that

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they alter and restrain the secretion in a very satisfactory manner.

Erysipelas.—The power of the remedy in this disease depends much on the mode of its application; the mere drawing of a line of caustic round the inflamed margin (as sometimes practised) is illusory. The best method is that of Mr. Higginbottom, who advises previous cleansing of the part with soap and water, then with pure water, and afterwards the thorough application of a saturated solution (20 gr. in each fluid drachm) two or three times over the whole affected surface, and beyond it on the healthy skin for about two inches. This is effective in the superficial forms of erysipelas, but not, according to my experience, when much œdema or cellulitis are present, and I am reluctant to advise it over an extensive surface, or in the idiopathic form. It causes severe burning pain, and in the latter condition, at least, does not always stay the inflammation, so that I prefer milder applications and appropriate internal medication.

Whitlow—Furuncle—Erythema.—These conditions are sometimes advantageously treated by the method of Higginbottom, but the solution may be made weaker, and nitrous ether employed as the vehicle: it does not dissolve so much as water, but 30 to 40 gr. in the ounce will be strong enough; this should be painted over the affected finger, or the commencing boil, or the inflamed and irritable patch. Chilblains are relieved by it, and it is said to prevent a threatened eruption of herpes if used early enough. To *bedsore*, in any stage, a solution of 5 to 10 gr. in the ounce may be applied with advantage.

Eczema.—The use of strong nitrate of silver in eczema should be reserved for chronic patches with much infiltration. Nitrous ether proves the best vehicle, because it dissolves sebaceous or fatty secretions, and allows the remedy to act better on the distended capillaries—30 to 40 gr. in the ounce may be used. Eczema in the neighbourhood of ulceration yields to lotions of moderate strength. For eczematous or aphthous conditions affecting the genital organs, or the nipple, and commonly accompanied with severe itching and irritation, a solution containing 4 or 5 gr. in the ounce should be first used in cases that are somewhat acute; but if relief be not given, a paint

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containing 30 to 40 gr. in the ounce should be carefully and lightly brushed over the part. Quite the best treatment for fissured nipples is to touch them thoroughly but lightly with a fine point of nitrate: all secretion should be cleansed from the part before such applications, and warm fomentations should be ready for use afterwards, as the pain may be severe. In abrasions or aphthous conditions about the mouth, the solid nitrate is one of the best remedies, although a painful one.

Burns and Scalds.—In superficial burns the strong solution has been applied, and to deeper injuries, when the true skin is affected, the solid stick has been used with the object both of forming a covering from air, and of lessening the degree of cicatrization (Fricke). This method has not met with general support, but a modified plan was recommended by Mr. Skey, who used a lotion containing about 6 gr. in 1 oz. for infants, and twice that strength for adults, covering the part immediately afterwards with cotton wool (Lancet, ii., 1861). A mixture with linseed oil has been commended (Wernher), and the solid stick is always useful in later stages when ulcerations are slow to heal. Hebra applies it once or twice daily, especially where there is liability to adhesions.

3. *Counter-irritant.*—The action of the remedy when applied locally in superficial inflammations, has earned for it the title of "caustique antiphlogistique," but we cannot recognize in it any distinctly caustic action, any more than we can verify the production of a "substitutive inflammation," which replaces for a time the original malady, and then itself subsides (*v.* p. 397). The main factor in the result is an astringent effect on the vessels and nutritive processes, but there are cases in which, when the nitrate is applied to some other than the affected part, it will relieve by an action which may properly be called counter-irritant or derivative, the "médication irritante transpositive" of Trousseau. Thus, Liston and Elliotson treated erysipelas by its application to the neighbouring *sound* skin, and Lubanski, Egan, and others treated amenorrhœa by pencilling the os uteri (Dub. Journ., 1848).

Orchitis—Synovitis.—In these deeper-seated inflammations benefit may be obtained from strong nitrate of silver applied on this principle of counter-irritation. The best position for the

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application has been much discussed, some placing it as near the part as possible, others insisting that it shall be between the heart and the inflamed tissue, and others that it shall affect vessels which receive their supply from a different source than the affected part. The simple rule adopted by Mr. F. Jordan, with much success, is to apply the nitrate over the *adjacent vascular territory;* thus, in orchitis he acts upon the great vessels in the groin and front of the thigh (Practitioner, vol. ii.). In synovitis it is used round the affected joint, though iodine is usually preferred in this disorder.

In irritation of the *prostate gland or seminal ducts*, it may be applied to the perineum, rather than to the urethral membrane itself.

4. As a *direct irritant* (the "medication excitative" of Trousseau), the nitrate finds some applications.

Hydrocele.—The solid stick may be applied, for instance, to the interior of a hydrocele-sac after evacuating the contents, but an injection through a trocar is more under control: the object is to excite sufficient inflammation to induce adhesion (this is now better effected by iodine).

Tumours.—Small cystic or fatty tumours may be cured by inducing moderate suppuration, and one of the best means for this purpose is the injection into their substance of a few drops of solution containing 1 part of silver nitrate in 6 or 8 of water; this mode of treatment was specially introduced by Luton, who termed it "parenchymatous substitution."

Neuralgia—Sciatica.—Luton applied the deep injection of this salt also to the treatment of these maladies.

In sciatica of chronic and obstinate character, 10 to 20 drops of the solution injected deeply near the seat of pain will lead to a localized suppuration which sometimes quite cures the original malady: it is best used in the nates at the point of emergence of the sciatic nerve.

In other chronic obstinate neuralgiæ, and according to Le Dentu in any deep-seated neuralgic pain of any part, similar treatment has proved of service: of a solution containing 1 part of nitrate in 5 of water he injects deep into the cellular tissue 2 or 3 drops: this causes acute pain for the moment, and sometimes a small abscess afterwards, but never serious

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trouble (Med. Record, 1877). Dureau, in a recent thesis (Paris, 1877), sums up very favourably the experience recorded up to the present time of this method of treatment; it is said to be both certain and rapid in its effects, and not to cause much irritation of the deep tissues. Luton himself used a 10 per cent., also a 5 per cent. solution, and others one of 25 per cent., injecting 5 min.,—all with successful results.

In **Chronic Joint-Disease, Synovitis, etc.**, equally good results have been recorded from the method of Luton—*i.e.*, deep injections into the joint-cavity (Med. Record, Nov., Dec., 1877). The process may be compared with that of Thiersch for cancer, in which weak solutions only are used, and suppuration is not intended (*v.* p. 395).

THERAPEUTICAL ACTION.—*Internal.*—The value of silver compounds is acknowledged in certain disorders of the gastro-intestinal mucous membrane, and of the central nervous system. In the former their action is a local one, doubtless of the same character as that exerted upon the external surface; in the latter they are given for a "constitutional" effect of tonic or indirectly sedative character, which may perhaps be resolved into a regulating or astringent effect upon the capillaries (Hudson, Lane). In support of this view has been quoted the power also possessed by these salts of moderating uterine and other discharges, but this is perhaps only contingent on the improved state of the stomach-functions; in the present state of our knowledge, however, the record of clinical facts is of more importance to us than the theories formed to explain them.

Dyspepsia — Chronic Gastritis — Chronic Gastric Catarrh. — The nitrate and the oxide are both valuable in many of these cases, and in judging of their suitability in a given instance, it is not easy, nor is it essential, to draw a definite line between functional and organic disorder. Gastric pain, especially when severe, and coming on some time after food, with tenderness, distension, pyrosis, and vomiting, are sufficient indications. Dr. J. Johnson, one of the earliest observers of this use of the nitrate, found that mental depression, or motor disturbance

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of convulsive character, furnished additional indications for it (On Indigestion, 1826). Dr. Symonds recommended it "in nervous irritability with passive or chronic congestion of the stomach." In Dr. Hudson's cases, pain of very acute character and long duration, with distension, thirst, constipation, and vomiting of sour fluid, were relieved within one or two weeks, but he gave the remedy (¼-gr. doses) with opium (¼ gr.), and hop (Dub. Journ., May, 1840). Dr. Osborne, a distinguished Dublin physician, found it valuable in gastralgia with "sour vomiting" (1831), and more recently, we find Dr. Spender praising it as the "best remedy in pyrosis" (Practitioner, Oct., 1868), and Dr. H. Wood, "in vomiting of much yeasty fluid." I should attribute importance to its disinfecting properties in such cases. Dr. Wilson Fox also adds his testimony to the "well-established reputation of the silver salts in chronic gastric catarrh," and places them next to bismuth: he would generally prescribe them, however, with opium, whilst Frerichs, also a high authority, gave them with belladonna. The absence or the presence of constipation will be a useful guide to the choice of these adjuvants. In gastritis, Dr. A. Fleming obtained very good results from the nitrate, and his mode of using it would seem to obviate, if that be necessary, the objection urged by Brinton, and to some extent by Husemann, viz., that the smallness of the dose, and the dilution and chemical change of the drug, must make it almost inert. Dr. Fleming was accustomed to order ½ oz. only of distilled water containing from 1 to 4 gr. of the salt, to be taken fasting, and in the recumbent position, the patient then to turn himself from side to side so as to insure contact of the remedy with different parts of the stomach wall. In some cases he even injected the dose directly into the viscus, with a syringe and perforated tube (Med. Times, i., 1859). Dr. Hartshorn valued the nitrate in chronic gastritis; he gave it in pill (Amer. Journ., July, 1849). My own use of the remedy has been generally in doses of $\frac{1}{20}$ to ¼ gr. every four or six hours in distilled water, and I have certainly observed from it much relief of discomfort and pain, flatulence, heartburn, and pyrosis, yet there is some uncertainty in

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its action (*v.* p. 415). Women suffering from the above symptoms, together with severe retching and vomiting of tenacious fluid, and a too frequent and profuse menstruation, are almost always relieved by it, but the maladies in question assume so many phases, and are more or less amenable to so many forms of treatment, that we cannot be surprised at difference of opinion as to the true value of this one.

It has naturally been thought that risk of caustic and irritant effects might be obviated, and equally good curative effects obtained by the use of the oxide of silver instead of the nitrate, and this was brought prominently before the profession by Mr. Lane (Med.-Chir. Rev., July, 1840–41), and afterwards, in a special treatise, by Sir James Eyre. The former records a number of cases with severe but intermittent gastrodynia, general uneasiness, nausea, and watery eructation, almost all relieved quickly by ¼ or ½-gr. doses of the oxide: nothing is said about diet or other adjuvant treatment. Mr. Lane states further, that if organic mischief have resulted —if the tongue be tumid and cracked, and the pain constant, or the ejected fluid "glairy" (as in Todd's "follicular gastric dyspepsia"), then the remedy is of no service; but it is not necessary to adopt these limitations if other indications for the remedy exist.

Uterine Disorders.—Dr. Hudson and others remarked the great improvement in certain uterine symptoms during the exhibition of silver, and recorded cure of many cases of menorrhagia, of uterine leucorrhœa, and of painful menstruation, though not with the scientific precision now expected. Many cases occurred at the menopause, some during pregnancy, and in several, a previous long sterility was followed by fecundation: simple vaginal leucorrhœa was not benefited.

Guided partly by this marked sympathy between the gastric and the uterine conditions, I have prescribed the oxide for nervous highly-sensitive women suffering from gastrodynia and pyrosis, with coincident uterine flux, and have often seen marked and immediate improvement in both symptoms, and without any drawback. The use of the medicine need not, however, be restricted to such cases; its action is somewhat

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similar to that of bismuth, and it may be used if that should fail to relieve. It has the advantage of being effective in a much smaller dose: $\frac{1}{10}$ to $\frac{1}{2}$ gr. is usually quite sufficient, and in the form of a minute pill this is readily taken. I have not seen the irritation from it which has sometimes been described, nor the salivation which might be produced by its too-prolonged use, nor any symptoms of argyria. It should not, however, be continued for many weeks consecutively. It is useful for cases in which arsenic also relieves, and an interesting fact is that this remedy and bismuth have often an equally good influence over uterine loss when connected or coincident with gastric disorder.

In the *cardialgia and vomiting of pregnancy* I have found it useful when many other remedies failed to give the slightest relief.

Gastric Ulcer.—In so serious an organic disease, which must, of necessity, often end fatally, it is not surprising if the powers of the silver compounds have been called in question. Cases of marked relief, if not cure, by these remedies have, however, been recorded (Stillé), and it seems reasonable to allow that if they can relieve ordinary gastritis, they may relieve the same condition when dependent on a local lesion; they lessen local congestion and local nerve-irritation, and in some cases, at least, they form a protective layer of albuminate, and probably thus relieve the pain of gastric ulcer.

Jaundice.—Dr. Peebles (U. S.) has recorded several cases of jaundice in which rapid improvement followed the use of nitrate of silver given in $\frac{1}{4}$-gr. doses twice daily for two to ten days: he attributes its good effects to its modifying the state of the mucous membrane, and relieving a chronic gastro-enteritis, and lessening the obstruction of gall-ducts by diminishing glairy mucus (Amer. Quart. Journ., July, 1849).

In *catarrhal jaundice*, with pain and functional stomach-disorder, Dr. Bartholow reports good results from similar treatment, which he compares to that by mercury or arsenic.

Chronic Diarrhœa—Dysentery.—I have obtained great benefit from nitrate and oxide of silver in many forms of these disorders—in serous diarrhœa, in chronic and periodic forms, in diarrhœa after fever, and in that of dysenteric character.

Graves preferred the nitrate (which he gave in grain doses)

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to any other astringent or to opium, but (as remarked by Stillé) he avoided it in cases of ulceration, when really its advantages may best be proved. Dr. J. MacGregor reports several cases of exhausting diarrhœa during advanced phthisis, in which the relief was marked and immediate; he gave the remedy also in 1-gr. doses with ¼ gr. of opium, and in enema (Brit. and For. Rev., Sept., 1841). I have myself often found it of the greatest advantage in such cases, restraining the profuse discharge, and aiding to strengthen the patient; I have given from $\frac{1}{10}$ to 1 gr. In the form of enema, containing 3 to 4 gr. in 2 oz. of distilled water, it is a valuable remedy for chronic dysentery and ulcerative conditions of the rectum; the enema may be repeated every six to twelve hours for three or four times, if necessary. If ulceration or congestion be situated higher up in the intestine, the nitrate is best given by the mouth in pill, since it is thus most likely to reach the affected part unaltered, and to exert the local action which is desired. The chloride of silver has also been used with advantage in chronic dysentery.

Diarrhœa of Children.—The nitrate has been recommended by Trousseau, Mauthner, etc. I do not think it advisable for acute cases, for it is uncertain in action, but in prolonged and obstinate cases a few doses often act well; they may be given by the mouth or rectum.

Typhoid Fever.—Dr. Pepper has recorded fifty cases of typhoid fever in which, after the second week, the medicinal treatment was nitrate of silver (¼ gr.), with small quantities of belladonna and opium; only one case was fatal, and he considers that these remedies act favourably by limiting follicular catarrh and modifying its secondary effects (Boston Journ., Oct., 1877).

Diseases of the Nervous System.—It is curious that silver was early appropriated to the treatment of cerebral disorders by the theories of astrology, which associated both the metal and the malady with the influence of the moon: by the time of Linnæus its medicinal virtues were so far distrusted that he describes only its "power as political, its use commercial." It retained, however, some reputation in epilepsy, and of late years there has been further evidence of a neuro-tonic

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power exerted by it rather upon the spinal than the cerebral nervous system, as illustrated in some forms of paralysis.

Epilepsy.—Unless we are wholly to reject past records and the opinion of distinguished physicians, the nitrate has given good results in a large number of epileptic cases. Heim considered it the best of remedies, and Trousseau, who used also the chloride, places the silver salts second only to belladonna (Traité, Ed. 1868). We need not, however, quote many authorities to the same effect: we recognize that it has relieved, sometimes even seemed to cure, cases of this disease, and may therefore, under certain conditions, relieve others. We should not, with Krahmer, consider it most suited for the robust, with symptoms of head congestion, but rather for the delicate with morbidly irritable and susceptible nerve-system, and a languid state of the organic functions (Stillé); it is in the pallid and anæmic that strychnia acts well sometimes (Tyrrell), and it is in similar cases that I should be hopeful of good results from silver. Curci considers that it does good in epilepsy connected with spinal disease, but when dependent on local lesion—as hæmorrhage, softening, or tumour—the malady is not influenced by it. More definite indications we cannot at present lay down, and must acknowledge that of any given number of cases, the majority at least will not yield to this remedy, and others, if they receive temporary benefit in the prolonging of the interval or lessened severity of the attacks, will ultimately relapse. The greatest objection to nitrate of silver, and one which has led to its comparative disuse, is the possibility of its discolouring the patient, and this even without curing his malady,—I have seen epileptics discoloured by the medicine, and yet suffering as severely as ever from their convulsions. Unfortunately the nature of the disease requires a long continuance of treatment, and therefore a medicine must be preferred which shall, at least, not inflict so visible an injury, and we need seldom prescribe the silver salt until a fair trial has been made of bromides, of belladonna, etc. If, however, it be decided upon, then a purgative should be given at the commencement of, and occasionally during treatment; the remedy should be omitted for a few days at intervals, and the gums should be carefully watched for signs of systemic

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saturation. The use of nitrate for *epilepsy in children* has been objected to by Lœbenstein, but I have seen it of service in chronic cases. Brenner recommends the chloride in infantile convulsions, and also in the brain-affections of typhus. Niemann found advantage from the ammonio-chloride in epilepsy and melancholia.

Paralysis—Ataxia.—We cannot speak with any confidence of the power of silver compounds to relieve serious or chronic cases of this kind, though there are not wanting records of improvement, more or less marked, obtained under their use. Wunderlich reported seven cases of ataxy arrested in progress under 5-gr. doses, two or three times daily; whilst Charcot and Vulpian related five cases that had lasted respectively two, four, five, and two of them fifteen years. A pill containing $\frac{1}{6}$ to $\frac{3}{4}$ gr. of nitrate was given daily for from thirty-five to sixty days, and in every case in the course of a week, improvement commenced as to sensibility, power of placing the limbs, as to sight, and especially as to lessening of pain (Mémoire sur le Nitrate, Bull. de Thérap., 1862). The report of such cases caused much sensation, but Topinard, who criticises them closely, asserts that in some the diagnosis was imperfect, and that admitting it in the others to be correct, there were unsuccessful cases to be compared with them, and many others unrecorded (De l'Ataxie Locomotrice, Paris, 1864). He has collected altogether twenty-eight cases, more or less favourable to the efficacy of the nitrate, and nine unfavourable; to these, he has added seventeen cases carefully noted under his own observation: commencing with $\frac{1}{12}$ gr. daily, he continued it for ninety days, interrupting the course every eight days for a week; then $\frac{1}{6}$ gr. was given for four months. In the first case reported, no good result was obtained, though erections recurred; at the end of the treatment the patient was worse, and the same has to be said of eleven other cases: in the remaining five there was some amelioration of symptoms. Althaus, on the other hand, has had, on the whole, a favourable experience with this remedy, and I believe that I have seen benefit from it in relieving the "lightning pains," and in arresting, for some time at least, disorder that was progressing, but it is no specific against locomotor ataxy.

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Diphtheritic and Mercurial Palsy.—A case of the former kind, cured under the use of nitrate, is recorded (Amer. Journ. Med. Sci., April, 1865, p. 485), but I am not aware of others. Fairly rapid recovery in six instances of mercurial palsy is reported by Seimentini with doses of from $\frac{1}{6}$ to 3 gr. daily (quoted by Dr. Waring).

Nerve-Debility—Headache.—In some few cases of nerve-debility and depression connected with overwork, anxiety, or excess, and exhibiting hypochondriacal symptoms—morbid fear, impaired mental capacity, and frequent rather deep-seated fixed headache—I have seen improvement under the use of nitrate, and have felt justified in connecting it with this drug, because iron, and bromides, and other remedies had been used without advantage, and the patient's mode of life and circumstances were not altered when the silver was commenced.

In *hysterical* or *nervous* headache it was valued by Dr. Graves, and others have found it useful in neuralgia, for which Paterson recommends especially the iodide. If the headache be accompanied with constipation or gastric disorder, an occasional laxative is required.

Various Diseases.—Other disorders, which may either be called "nervous" in character, or are connected at least with reflex nerve-disorder, and which the salts of silver have been found sometimes to relieve, are such as *chorea*, *angina pectoris* (Copland, Dict.), *spasmodic asthma* (Waring, Curci), *palpitation* (Kopp), *vertigo* (Rademacher), *pertussis* (Berger): for this last the iodide is especially recommended. They have been given also in more general diseases, as *intermittents* (Sokolow), *diabetes*, and *phthisis* (Brady, Moore), the object desired in these latter cases being mainly to lessen the excessive discharges from the kidneys, the skin, and the bowels; in some instances they have certainly succeeded, though we could not expect them to alter the ultimate termination of such maladies. In *dropsy* the nitrate was given by Boerhaave as a purgative in 2-gr. doses, and has been more lately commended by Dreyer (Husemann). In *syphilis* the chloride and oxide were given by Serres and others, but their value has been disproved by Ricord. The ammonio-chloride has been used as a cathartic and a vermifuge.

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PREPARATIONS AND DOSE.—*Argenti nitras:* dose, $\frac{1}{6}$ to $\frac{1}{3}$ gr. (B.P.); it may vary from $\frac{1}{10}$ to $\frac{1}{2}$ gr., and more has been sometimes prescribed. *Argenti oxidum:* dose, $\frac{1}{2}$ to 2 gr. in the form of pill.

The dose of the *chloride* is about the same as that of the oxide, though upwards of 30 gr. have been given without gastric pain (Trousseau): the dose of *iodide* and other salts is also about the same as the oxide.

As a caustic the solid nitrate may be used alone, or "mitigated"—*e.g.*, with nitrate of potash (Crayons de Barral, de Desmarres), or with sulphate also (Guyot). In default of a metal, or caoutchouc, or quill holder, melted sealing-wax forms a convenient coating, and a file, or friction with wet lint, sharpens the point better than a knife: for small fistulæ or numerous leech-bites, a silver probe, dipped as required in the melted salt, is very convenient. The finely-powdered nitrate, diluted (as with sugar), has been used for the throat and larynx, and abroad, charpie, dipped in a strong solution and dried, is used as a dressing for indolent wounds, and known as the black or caustic charpie of Riboli (Husemann).

Of solutions, 40 gr. in the ounce will prove caustic to mucous membranes, and from 80 gr. upwards caustic to the skin; distilled water, glycerine, or nitrous ether may be used as solvents (*v.* p. 401); opium may be added to diminish pain, and after a strong application the part, especially if it be the eye, should be bathed with warm salt water to neutralize any excess of caustic—20 gr. to the ounce is a useful strength for an astringent solution, but a proportion of 10, 5, and even 1 gr. to the ounce is suitable according to the condition of the affected part, and may be used in lotion, injection, or collyrium, as already described, it being remembered that the weaker solutions require to be used the more frequently: the disadvantage of the salt staining linen must be borne in mind.

Both the nitrate and oxide have been used in stimulating and astringent ointments: thus, in the Hamburgh Pharm., 15 gr. are ordered with 1 dr. of Peruvian balsam and $\frac{1}{2}$ oz. of zinc ointment (Ungt. Nigrum), and Lane used the oxide in specific and other ulceration, but I do not think ointments a good form of the remedy.

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Since the salts of silver are readily decomposed, they should be mixed as little as possible with organic or mineral substances, and haloids, sulphides, alkalies, soaps, tannin, and astringent extracts should be excluded from prescriptions for silver compounds: it is important to mention, also, the exclusion of creosote, for explosions have occurred from its trituration with oxide of silver and organic substances. Solutions of the nitrate for internal use should be kept as much as possible from air and light, and are therefore commonly ordered in covered or dark-glass bottles: they may be made with distilled water or with glycerine, and sometimes a few drops of nitric acid are added to prevent reduction; syrup may be given with it for children. Delioux prescribed it with an equal part of salt in a weak, sweet, albuminous solution (white of egg), and Deniau added to this a small proportion of bromide of potassium to re-dissolve the precipitate; but in such combinations, the object of which is to secure solubility and absorption, we are not giving the nitrate, but a complex chloro-albuminate. Discoloration of the lips and teeth, and nauseous taste, are, however, drawbacks to the use of any solutions. A pill may be made with crumb of bread according to an old and well-known formula (Boudin): the decomposition into chloride that may occur is unimportant (*v.* p. 386). Argilla and silica and chocolate have been recommended as vehicles.

The oxide is always given in pill or confection, and this form is to be preferred for "constitutional" effects, or for an action on the lower parts of the intestinal tract. It is usual to direct a patient taking these medicines to abstain from much salted food before or after the dose, as likely to hinder absorption into the blood.

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ARSENICUM—ARSENIC, As, = 75.

The name arsenic is applied by common usage both to the element and to its *oxide*, which is more correctly termed arsenious anhydride; it is also called white arsenic, or arsenious acid.

The element, formerly classed with metals, now with metalloids, occurs sometimes native, but generally in alloy with iron, copper, and other metals, as oxide and sulphide. Nearly all sulphur contains some arsenic, and from these different compounds it is liable to pass undesignedly into many pharmaceutical preparations. Mineral waters also frequently contain it; Tripier has noted its almost constant occurrence in chalybeate, and Thénard in saline springs, though in minute proportion: those of Plombières contain but 0·0008 gr., Vichy 0·01 gr., and La Bourboule (the largest amount) $\frac{1}{10}$ gr. in 16 oz.

CHARACTERS. — The metalloid is a steel-grey solid of metallic brilliancy, readily oxidizing and tarnishing on exposure to air. It volatilizes at a dull heat, the colourless vapour having a garlic-like odour. It burns when heated in the air.

ACIDUM ARSENIOSUM—ARSENIOUS ACID, OR ARSENIOUS ANHYDRIDE—WHITE ARSENIC, As_2O_3, = 198.

PREPARATION AND CHARACTERS.—Arsenious acid is prepared by sublimation from arsenical ores, and condenses in the *cooler* parts of the retort as a heavy powder, fine and white, like flour; in the *hotter* parts, it forms a vitreous mass, transparent and amorphous, which becomes, on exposure to air, opaque and crystalline, and is usually seen in smooth milk-white or yellowish pieces not unlike porcelain, and stratified in appearance according to the different opacity of its layers; the change from the amorphous to the crystalline form is accompanied with phosphorescence (one of several of its analogies with phosphorus). The two forms differ in density and in solubility, the transparent acid dissolving in about 100, the opaque in about 80 parts of water at 15° C.

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The powder is not readily wetted by water, so that it is apt to remain floating on the surface, or adherent to the sides of a vessel. Organic products, milk or mucus, render it *less*, acids and alkalies *more* soluble; oils and alcohol also dissolve it. It crystallizes from a saturated solution, or after slow sublimation in minute shining octahedra, or in rhombic prisms (like oxide of antimony, with which it is isomorphous): sprinkled on a red-hot surface, it evolves scarcely visible vapours of metallic arsenic, which have an odour like garlic, and, at a few inches from the hot surface, change to dense white odourless smoke, being the acid re-formed by oxidation. Arsenious acid itself has no smell: its taste is sharp and rather nauseating (Hirtz), but in such small quantities as may be taken for trial, nothing more than a slight sweetness and grittiness will be detected (Christison).

LIQUOR ARSENICALIS—ARSENICAL SOLUTION—FOWLER'S SOLUTION.

PREPARATION.—By boiling together arsenious acid and carbonate of potash, and adding to the solution (when cold) tincture of lavender, and sufficient water to preserve a proportion of 4 gr. in the ounce.

CHARACTERS.—A reddish, alkaline liquid, with the odour of lavender: it contains a mixture of arsenite and carbonate of potash.

LIQUOR ARSENICI HYDROCHLORICUS—HYDROCHLORIC SOLUTION OF ARSENIC.

PREPARATION.—By boiling arsenious acid with hydrochloric acid and distilled water, preserving a proportion of 4 gr. to 1 oz. (This solution corresponds in strength with liquor arsenicalis; it is nearly three times the strength of liquor arsenici chloridi, Lond., and of the original acid solution of De Valangin.)

CHARACTERS.—A colourless liquid of acid reaction and sp. gr. 1·009.

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SODÆ ARSENIAS—ARSENIATE OF SODA.

PREPARATION.—By heating together arsenious acid, nitrate and carbonate of soda, dissolving and crystallizing.

The *liquor sodæ arseniatis* contains 4 gr. of the anhydrous salt in 1 oz. of distilled water.

CHARACTERS.—The salt occurs in colourless transparent prisms soluble in water and alkaline in reaction: the *solution* is also colourless and alkaline.

Arsenic Acid, As_2O_5, the higher oxide of arsenic, is also white and solid, but is so soluble as to be almost deliquescent, and it has a strong acid reaction. It is not employed in medicine in its free state, but in combination with soda and iron. In the arts it is largely used in the printing of cotton stuffs, and in the manufacture of aniline dyes.

Ferri Arsenias—Arseniate of Iron, $Fe_2As_2O_8$ (*v.* p. 558).

Liquor Arsenici et Hydrargyri Hydriodatis.—A solution (not officinal) containing a double iodide of arsenic and mercury, has long been in use under the name of its proposer—Mr. Donovan, of Dublin (1839). It is a pale-greenish coloured liquid, having no odour, but a styptic taste; it probably contains the red iodide of mercury and ter-iodide of arsenic. In each fluid drachm there is about $\frac{1}{10}$ gr. arsenic, $\frac{1}{4}$ gr. mercury, $\frac{3}{4}$ gr. iodine.

TESTS.—1. Sulphuretted hydrogen gives a bright yellow precipitate of arsenious sulphide (As_2S_3) in acid solutions of arsenious acid or the arsenites.

2. *Hume's Test.*—Ammonio-nitrate of silver gives a lemon-yellow precipitate of arsenite of silver (Ag_3AsO_3) in solution of arsenious acid, or the arsenites. The same silver-salt gives a similar reaction with phosphoric acid, but with arsenic acid and the arseniates, a chocolate-coloured precipitate of arseniate of silver (Ag_3AsO_4).

3. Ammonio-sulphate of copper gives with compounds either of arsenious or arsenic acid a light-green precipitate of arsenite of copper ($CuHAsO_3$), Scheele's green.

4. *Marsh's Test.*—Generate hydrogen by the action of a hot solution of caustic potash or soda on zinc ($Zn + 2KHO = K_2ZnO_2 + H_2$). Fleitmann has shown that antimony will

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not combine with this form of hydrogen, but that arsenic will. Place the solution to be tested in a "Marsh's apparatus," and if arsenic be present it will combine with the nascent hydrogen to form arseniuretted hydrogen ($As_2O_3 + 6H_2 = 3H_2O + 2AsH_3$). On igniting the jet of gas (which burns with a bluish flame), and depressing upon it a cold porcelain plate, an arsenical stain will be deposited, whilst the hydrogen is burned off into water. The stain has the following characters:—(*a*) metallic brilliancy; (*b*) hair-brown colour; (*c*) volatility; (*d*) solubility in chloride of lime; (*e*) non-solubility in cold disulphide of ammonium; (*f*) when evaporated with a drop of nitro-hydrochloric acid it yields a residue of arsenic acid, which gives a brickdust-red turbidity on the addition of nitrate of silver.

5. *Reinsch's Test.*—A piece of copper foil, when boiled in an acid solution of an arsenical compound, will become slate-grey from the deposition of a fine film of metallic arsenic. This test, to be complete, must be verified by heating the coated copper in a narrow glass tube, when metallic arsenic will sublime, and be deposited in a ring on the cooler part.

For the "reduction test" of white arsenic, it should be placed with "black flux" in a similar tube perfectly dry, and on heating first the charcoal and then the arsenic, the latter sublimes and is deposited in a metallic ring as above mentioned.

ABSORPTION AND ELIMINATION.—Since the observations of Schmidt, Mialhe, and others, *metallic* arsenic has been considered inert. Recently, however, Schroff has shown that it may exert a strongly poisonous action, and that doses of 8 to 15 gr. have caused gangrene of the stomach and death in thirty to forty hours (Zeitschrift der Arzte, i., 1858). It is probably oxidized before absorption.

Arsenious acid in all its combinations, and by whatever channel introduced—by mouth or by rectum, by the lungs or by the skin—is readily absorbed, and has been detected in the blood a few minutes after its administration. It passes out by the skin and mucous membranes, by the various glands, as the salivary and even the lachrymal, but mainly by the kidneys.

The rapidity of elimination varies; in some cases, none of the substance could be detected in the secretions three days after

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the last dose, but in Ludwig's observations on animals, if small quantities were given for a fortnight and then omitted, the urine was not quite free till three weeks afterwards (Med. Record, 1877). Gubler gives six weeks as the time during which it may continue to pass out, and when it has ceased to do so it may reappear after administration of iodide of potassium; hence it seems probable that elimination is not always complete, and that of what is taken, a part may be deposited in the tissues and occasion so-called "cumulative" effects. Recently, arsenic has been found to be specially deposited in the *nervous* system; thus, if in fresh muscle 1 part is found, the proportion in liver is 10·8, in brain 36·5, and in spinal cord 37·3 (Scolosuboff, Annales d'Hygiène, Jan., 1876). This became a matter of great importance in a recent French trial (Danval), when the experts were blamed for not examining the brain and cord (B. M. J., ii., 1878, p. 73); these parts should henceforth be analysed as carefully as the abdominal viscera. Caillol (de Poncy) offers some analyses to show that arsenic partly displaces phosphorus in nerve-compounds (Med. Record, 1878). If any be contained in the body at death, it may be detected after an almost indefinite period.

PHYSIOLOGICAL ACTION.—*External.*—Preparations containing arsenic produce local irritation, inflammation, or destruction of tissue, in varying degree, according to the strength and character of the application. Dry white arsenic in mass may not injure the unbroken skin, but arsenical powders are apt to produce eruptions of various kinds on exposed surfaces, and especially irritative effects on the pudenda, in those who are employed in the manufacture of green dresses, wall papers, artificial flowers, etc. (Annales d'Hygiène, Dr. Guy, B. M. J., ii., 1863, etc.) Perforation of the septum nasi has been noted, and anal ulceration has followed the local use of a green paper coloured with arsenite of copper. Arsenic dissolved or moistened is still more irritating, and those who use it, for instance, in sheep-washing, generally suffer from eczema of the scrotum, etc. (Lancet, 1857). Those who work with arsenical powders are liable also to various degrees of acute and chronic arsenical poisoning; and green colours are not the only dangerous ones:

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fuchsine, a *red* dye, contains much arsenic (Ludwig, Med. Record, 1877), and *blue* gloves have shown arsenic on analysis (B. M. J., ii., 1878). The use of green-coloured cards has caused a disease of the nails resembling psoriasis, and green hat-lining has caused eczema (Farquharson, B. M. J., ii., 1879). The external use of a violet powder adulterated with arsenic proved fatal to thirteen children out of twenty-nine subjected to it (B. M. J., ii., 1878).

The continued application of a strong arsenical compound has a caustic, destructive effect, which is not simply a *chemical* one, like that of caustic acids or alkalies, and is not exerted on the dead subject (Hirtz), but is produced by interference with nutritive processes in the part, causing rather a condensation and "mummifying" of tissue than an actual destruction (Gubler). It is much more active in unhealthy, ill-nourished tissue (*e.g.*, that of lupus), than it is in normal tissues. Very strong arsenical applications produce much local inflammation, and so far interfere with the action of absorbents that the effect remains local only; but unless in such strong concentrated form, arsenic is readily absorbed, especially from wounds and mucous surfaces; hence its surgical use has led to serious constitutional symptoms, and even to death. Roux describes the application of an arsenical ointment—1 part in 32—over a space of 1½ square inches of a cancerous breast for one night only, and death from poisoning on the second day. Sir Astley Cooper relates a fatal case from the use of an arsenical solution to a "fungus of the eye" (Lancet, i., 1837).

Arsenical paste applied to an inflamed tooth-pulp has also proved fatal, and Graham has recorded vomiting, severe pain, convulsion, and death from the use of a plaster containing half its weight of arsenic to a cancerous breast (Glasgow Med. Journ., 1869); the prescriber of the plaster was tried for homicide, and many similar cases have been before the law courts.

The *antiseptic* power of arsenic deserves mention: it is largely utilized in the dissecting room, and seems to have retarded the process of post-mortem decay in some cases of poisoning when large amounts have been used. The recent researches of Johannsohn assign it, however, but a limited power: he found that small quantities checked fermentation in yeast and syrup,

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but only for a time: in lactic fermentation it diminished the growth of one fungus, but favoured another. The same thing occurred in urine: it exerted no influence on non-organized ferments, such as pepsin, amygdalin, etc. (Archiv f. Exper. Path., Bd. ii., p. 106).

PHYSIOLOGICAL ACTION.—*Internal.*—The blood and the nutrition-processes are altered by arsenious acid and its compounds, but the symptoms of its physiological action are mainly evidenced in the *alimentary canal*, the *mucous membranes*, and the *nervous system*, and in different cases these parts are affected in different degree, according to the dose, the time and mode of its administration, and the constitution of the individual.

Digestive System. — Very small doses, such as $\frac{1}{30}$ to $\frac{1}{15}$ gr., may be taken for some time without other effects than such as are of stimulant and tonic character—*e.g.*, improvement of appetite, sense of warmth at the stomach, and general invigoration; but usually, sooner or later, these symptoms are replaced by those of irritation and malaise. Trousseau quotes from Kœpl the case of a servant who, desiring to get rid of a severe mistress, mixed with her food for some time very small doses of arsenic: the mistress, however, improved in appearance and in stoutness, and the plot was only detected after the use of a large poisonous dose. Doses of $\frac{1}{10}$ to $\frac{1}{2}$ gr. are liable to produce soreness of mouth, with some salivation and dysphagia, fœtid or sour taste, thirst, heat and constriction in pharynx, with nausea or vomiting, gastric pain, flatulence amounting to tympanitis, and diarrhœa. Vaudrey found copious pultaceous stools follow the medicinal use of arsenic without toxic symptoms. One of the early symptoms of the physiological action of the drug is a slimy silvery aspect of tongue, "as if nitrate of silver had been lightly applied" (Begbie), an appearance produced by a thin coating of mucus secreted under the influence of irritation. After continued doses, the tongue becomes red or brown, cracked and tremulous, the gums bleed, and the bucoal membrane becomes covered with aphthous or even membranous patches like a true diph-

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theritic condition (B. M. J., i., 1862). Vomiting becomes so frequent that all food is rejected, and emaciation sets in rapidly, an effect which has been termed "tabes arsenicalis."

After poisonous doses, which may be stated at 2 gr. and upwards, the symptoms already described become intensified; pain especially of most severe burning, cramping, spasmodic character comes on within half to one hour, in the region of the stomach and navel, spreading thence over the whole abdomen, which becomes contracted and hard: the ejecta are offensive, and yellowish or greenish in colour, not unlike bile (unless, as often occurs in cases of poisoning, soot or indigo has been mixed with the arsenic); hiccough attends the vomiting and purging; the latter becomes involuntary, and is accompanied with severe tenesmus, and the general symptoms may closely simulate those of cholera (Lancet, ii., 1870).

On the other hand, in some exceptional cases, the vomiting has been only moderate, and there has been complaint of coldness rather than heat; in others, there has been almost entire absence of pain, the patient remaining in a dull and semi-narcotized condition, and in several even severe cases, a remission of symptoms has occurred for some days before death (cf. Taylor, Guy's Reports, 1850).

In experimenting with frogs, Dr. A. Lesser found that intestinal peristalsis was increased by arsenic, and local tetanic contractions occurred from immediate irritation of ganglia in the intestinal coat (not indirectly from influence of the central nervous system): gastro-enteritis was also produced by the drug, but he did not, as Böhm did, find it more poisonous when given by the mouth than by a vein. It was eliminated by the intestinal mucous membrane (Virchow's Archiv, 1878, Lancet, ii.), and we may add here that by whatever channel toxic doses of the drug are given to men or animals, gastric inflammation is commonly determined.

Nervous System.—The early effects of very small doses are usually tonic in character, there being a general sense of improved power. The same fact was noted when describing effects on the digestive system, and it is possibly not a primary nerve-tonic effect, but rather dependent on improvement in appetite and assimilation of food.

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Full medicinal doses, long-continued, give rise to numbness and pricking sensations with tremor or stiffness of limbs.

Irritant doses cause gastric pain, as already described; sometimes *headache* has been a marked symptom, as, for instance, in a large number of children who each received about 1 gr. of white arsenic in milk (Taylor on Poisons, p. 295), and in many persons poisoned by the accidental admixture of a small quantity of arsenic in bread: they suffered also from a feeling of constriction over the forehead, vertigo, and tinnitus (Dr. Feltz, Lancet, i., 1880), from visual sensations of light or flame, prostration, and feebleness of lower extremities, and in these, as well as in other cases, pain in the back has been urgent (B. M. J., i., 1873). Sometimes the extremities have been very sensitive. Restlessness, insomnia, grinding of teeth, giddiness, irritability, and depression are frequent symptoms.

The effects of *poisonous* doses (6 to 8 gr.) are often ushered in with rigor, profound depression, and extreme anxiety. Restless tossing of arms is commonly noted, and later, numbness, cramps, and twitchings of all muscles. The œsophageal spasms may simulate those of hydrophobia, and the muscular cramps may amount to opisthotonos—convulsions alternate with delirium, the special senses become impaired or lost, the mental faculties torpid (the stupor may suggest narcotic poisoning), and syncope or collapse may close the scene. There may be local palsies, as of limbs and sphincters in the course of arsenical poisoning, and as the effect of the drug in this direction is not so generally known, we may, with advantage, speak of it more fully.

Arsenic exerts a paralysing influence certainly upon sensory and motor, and we may say *probably* upon vaso-motor nerves also. Dr. Sklarek, experimenting on the frog, found that arsenical injections, in minute quantities, destroyed common sensibility, probably by influence on the cord (Reichert's Archiv, 1866). Lesser, whilst verifying this, noted a transient increase in reflex irritability, then diminution of it, then cessation; after some time the frog became completely paralysed.

Drs. Ringer and Murrell, remarking that paralysis occurs in the same order after *mechanical arrest of circulation* (as by ligature or excision of heart), instituted experiments to show whether the latter was the real factor in Shlarek's results.

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and concluded that they were due rather to a toxic action on the central nervous system; peripheral motor nerves retained their function for some time, for the muscles continued to contract under direct galvanic stimulus; ultimately both nerves and muscles were paralysed by arsenic, and they ceased to react long before similar muscles did in a *brainless* frog, and the observers named conclude that "arsenious acid is a protoplasmic poison, affecting first the more highly organized nervous centres, next the nerves, and last the muscles: . . . that it is a poison to all nitrogenous tissues (Journal of Physiology, i., 1878–79, pp. 227, 228).

Clinical records clearly indicate *paralysis* as a symptom of arsenical action. So early as 1711 Morgagni notes "tremor of limbs, and palsy of feet" (Op., vol. iii., Trans. Alexander, Letter 59). Mr. Trend reports the case of a pregnant girl, who took 2 gr. twice daily for three months, and besides intestinal symptoms, suffered from pricking pain in both legs, impaired sensation, and loss of power (B. M. J., ii., 1858). Partial paralysis and numbness from habitual taking of the drug are recorded in Schmidt (Bd. clxv., p. 238). and tremor and partial palsy from exposure to arsenical vapour in aniline works, by Dr. G. de Mussy (Lancet, i., 1876). Dr. Leroy (d'Etiolles), who has written specially on the subject, describes a case of paraplegia succeeding to acute arsenical symptoms after the application of a caustic paste to a cancerous breast, and another aggravated case of paraplegia, weakness and anæsthesia of arms with diarrhœa, and ultimately death from marasmus (Gaz. Hebdom., 1857).

Christison has remarked that arsenical palsy resembles that of lead in its character, and Gubler and Duchenne have found it sometimes identical. Leroy, however, points out that it not so invariably affects the *extensors*, and that it is more generalized.

The *wasting* of limbs is more general, and they may become semi-flexed; when all are affected, the upper recover before the lower,—a point of difference from cerebral palsies. An average duration is from four to ten months, and the prognosis is favourable under treatment.

Circulatory System.—After administration of arsenic, analysis has detected it in the clot—*i.e.*, united with the globules, and

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not simply dissolved in the serum. Claude Bernard taught that it acted on the corpuscles in such manner as to diminish the activity of interchange of oxygen and carbonic acid (Med. Times, ii., 1861). The experiments of Brodie had already indicated *undue fluidity* of blood as an effect of arsenic, and modern observations refer this condition to a solvent action on hæmoglobin: thus, if arseniuretted hydrogen be passed into defibrinated blood, it becomes black, and gives with the spectroscope one large dark band instead of the two normal ones; by degrees, the spectrum wholly disappears, the hæmoglobin is destroyed, and the liquid turns yellowish-green. It seems probable that the same gas is developed to some extent from arseniates absorbed into the living organism, and that it exerts a similar destructive action on the globules; this would explain the anæmia, and the consequent œdema and anasarca, met with after continued use of even medicinal doses, as well as the icteric tint of skin, and the petechiæ and hæmorrhages in cases of poisoning. Though there is evidence that in certain forms of anæmia the number of the corpuscles is increased under arsenic (Gowers, Practitioner, July, 1878, and Bramwell), there can be no doubt, that an opposite result follows both its long-continued use in disease, and any appreciable quantity of it taken by healthy persons. Thus, Lemare-Piquot (Honfleur), suffering from cerebral congestion, had himself bled many times, and by careful observations of the proportion of clot to serum showed that the continued use of arsenic could markedly lessen the former. The normal maximum proportion of clot he reckoned at 54 per cent.; with any amount above this, cerebral symptoms, such as giddiness and oppression, appeared. In October, 1845, when suffering from such a condition, he found, on being bled, that the proportion of clot was 68 per cent., the serum being at 32 per cent. only. During the next four years he was bled more than twenty times with but partial and temporary relief. In March, 1849, he began the use of arsenical solution in small doses twice daily, at that time his proportion of clot being 69 per cent. After one month's arsenical treatment he felt well, and the proportion found on bleeding was reduced to 52 per cent.

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In succeeding years the same result occurred several times; he illustrated it also in other cases, and concluded, both from analyses and clinical results, that arsenic always rendered the blood less plastic, and lessened the number of globules (Bull. de Thérap., t. lvii., 1859). More recently Cutler and Bradford also found red and white corpuscles to be diminished in number under arsenical medication, and Malcolm Morris reports diminution in some cases of psoriasis when the general health was good—*e.g.*, F., aged twenty-three, on August 14th, showed 58 corpuscles in each square (of Dr. Gowers' instrument), was ordered Fowler's solution (♏v. ter die), and on 21st showed 48 only per square: continuing treatment, on September 11th there were only 37·3—the eruption was nearly gone (Practitioner, 1880).

The force and frequency of the heart's action and the activity of the capillary circulation are usually increased by minute doses (Feltz, Harless) and especially in weakly persons (*v.* p. 429): larger quantities induce palpitation with quick, small, and irregular pulse; the face is flushed, while the extremities are cold.

Poisonous doses markedly depress the circulation, and ultimately arrest heart-action (in diastole) in the lower animals, as found by Sklarek in batrachia and in cats—there was no previous stage of excitement (Reichert's Archiv, 1866). Although the frog lives on for ten minutes after arrest of cardiac action, no stimulus will re-excite this, and yet irritability of cardiac *muscular* tissue persists, so that Sklarek concluded that arsenic paralysed the motor ganglia of the heart. Unterberger also records a very pronounced fall in the blood-pressure and pulse-rate (Archiv für Exper. Pathol., Bd. ii.). There is clearly a direct depressant effect on the heart—in fact, this causes death in cold-blooded animals, though not usually in warm-blooded. Some palsy of vaso-motor nerves is also indicated, and according to several experiments, this is limited to the abdominal division of those nerves: the exact explanation, however, requires further development. Though Lesser verified Sklarek's observations he did not come to the same conclusion that arsenic causes death by paralysis of the heart, but denies it for the simple reason that frogs survive excision of the heart for more than

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thirty minutes, whilst arsenic kills them in ten minutes. Ringer and Murrell found (in frogs) a *varying* effect upon the heart, it being sometimes completely arrested, sometimes continuing to beat after complete general paralysis, but they explained the difference by a variation in dose; a large one being quickly absorbed and conveyed to the heart arrests it at once, leaving little for the circulation to distribute, whilst a small dose paralyses the central nervous system before the heart (loc. cit.). In warm-blooded animals the pulse-rate was increased at first by small and medium doses injected into the veins, afterwards it was diminished; by a large dose, it was decreased at once, and blood-pressure reduced. The increase of the pulse-rate was traced to lessened influence of the vagus, and increased action of cardiac ganglia, the decrease of pulse-rate to contrary conditions. Stimulation of vaso-motor centres was not marked unless injections were made directly into the carotid, and Lesser could not verify paralysis of those centres under any conditions (Virchow's Archiv, 1878). In the human subject, the pulse usually becomes weak, rapid, and gradually more irregular till heart-action ceases: venous stasis naturally occurs, and there is pallor, lividity, and finally cyanosis of the surface and of visible mucous membranes.

Respiratory System.—Lesser verified a markedly stimulant effect of small doses, both on the respiratory centre and on the pulmonary terminations of the vagi; large quantities, on the other hand, extinguish nerve-irritability in these parts. That the effect is directly on the *centre* is clear from its occurrence even after section of the trunks of vagi, but when these nerves are entire the effect is greater, so that they have some share in it. Small doses taken under certain conditions—as, for instance, by the Styrian mountaineers—render the respiration easier, less laboured, and less hurried under severe exertion. On the other hand, even medicinal doses, if long-continued, will induce in some persons a dyspnœa, allied to that of emphysema or even asthma, with dry cough or hawking of mucus. This I have verified several times in the subjects of eczema, observing its cessation with the omission of the drug, and its return under arsenical influence; there may be also hoarseness, coryza, tonsillitis, or even, according to some observers, bronchitis (McCall

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Anderson), probably from irritation excited in the bronchial mucous membrane by the elimination of the drug; it has certainly some special determination to the pulmonary tract. After large poisonous doses the dyspnœa is often urgent, and the respiration stertorous.

Cutaneous System.—In frogs, one effect of arsenic is to cause a ready peeling or stripping of the whole cuticle some hours after hypodermic injection (Ringer and Murrell). In man, small doses, continued for a limited time, improve the skin-condition, and often (but not always) impart freshness and ruddiness to the complexion, whilst in animals they render the hairy coat more glossy and bright. Köhler remarks that since arsenic is eliminated by the sweat-glands (especially when they are acting vicariously for the kidneys), there is nothing remarkable in its modifying the circulation and nutrition of the skin, and its effects are explained by a capillary congestion and the presence of more blood in the superficial vessels, and this again has been attributed to a vaso-motor palsy allowing dilatation of such vessels.

Rabuteau thinks such a view cannot be accepted, because temperature is not raised as it is in experimental vaso-motor palsy—*i.e.*, after sections of sympathetic. This, I think, is a question of degree—the rise might be more or less according to the amount of paralysis induced by a drug—it would not be so complete as after section. Moreover, Harless reports a distinct rise, though recent experiments indicate a fall of temperature as the more *usual* condition connected with arsenical action (Lolliot). Rabuteau prefers to explain the florid colour by an "altered appearance of the globules."

When the drug is omitted after continuous use, an opposite condition—one of pallor and anæmia—is said to follow (Med. Times, ii., 1854). Certainly arsenic, if long-continued, leads to an unhealthy, dry, and somewhat scaly condition of skin, which has been called by some *pityriasis*, and by others even *psoriasis*, though I have never seen anything like a true case of the latter malady thus caused. Rabuteau observes, "We never see squamous affections from arsenic, contrary to the assertions of homœopaths" (Elements, p. 200).

Perhaps the extreme and most characteristic cutaneous result

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of arsenical saturation is a brown colour of the face and various parts of the body (Kirchgässer, Centralblatt f. Med., 1868). It is not common, but has been sometimes seen in such a form as to resemble argyria. Prof. Wilson gives the following illustration:—A lady had taken for fifteen months comparatively large doses of arsenic for gutta rosacea, and two months after commencing the medicine, a change of colour had been noticed in the skin, first over the abdomen, then on the breast, neck, face, and hands. When seen by Prof. Wilson the face was yellowish-brown, the eyeball dark, the whole body coloured more or less; chronic erythema affected the palms, there were hard dry points at the sweat-glands, the eyelids and the extremities were œdematous (Journ. Cutan. Med., vol. i., p. 354). In some of Mr. Hogg's cases, children got a "dusky skin-eruption in patches" from arsenical wall-papers (B. M. J., i., 1879). Such a condition depends not on chemical combination (as with silver) but on abnormal pigmentation (Gubler).

Cold clammy perspirations have also been connected with arsenical action, and pustules and ulcerations have sometimes followed it. In acute cases, either of poisoning or of unusual susceptibility to the action of the drug, patches of erythema or of urticaria (local congestions of skin) and even acute general lichen may occur. Macnab recorded an eruption like measles produced by 3-min. doses of Fowler's solution daily for three weeks (Med. Times, i., 1868), and Wyss says that he traced to it a case of alopecia areata—from affection of the trophic nerves of hair-follicles (Archiv der Heilk., 1870, Hft. i.).

Amongst rarer consequences, erysipelas with bullæ has been credited to arsenic, herpes has been traced to it by Mr. Hutchinson, and an obstinate eczema by Dr. Balfour (Edin. Med. Journ., 1860). Dr. Imbert Gourbeyre has specially written on arsenical eruptions, and in cases of acute poisoning when the patient survived several days, has seen them petechial, papular, vesicular, and pustular.

A degree of cutaneous swelling, characteristic enough to have received the name "*œdema arsenicalis*," usually occurs first about the eyelids and suborbital tissues, and is one of the earliest symptoms of constitutional action. In severe cases it may affect the extremities and even the trunk, and

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amount to general anasarca, as recorded so early as 1819 (Edin. Med. Journ., v. 15). In Dr. Feltz's cases already referred to, there occurred, on the second or third day, swelling of the eyelids and conjunctivæ—in some instances of the whole face, with a rash like scarlatina or urticaria. In most of them there was itching of the surface, and scratching gave rise to an urticarial rash; in one man the same eruption, together with herpes, appeared on the scrotum.

Mucous Membranes.—We have already noted characteristic arsenical effects upon the membrane of the mouth and intestinal canal. The lips, the nose, especially at its orifice, the anus, and the vulva often become similarly irritated and inflamed, and urethritis has been traced to medicinal doses of arsenic (Med. Record, 1878). On the mucous membrane of the *eye* the effect of the drug is often very early seen, so that it becomes a useful index of the degree of physiological action. Itching about the lids is first complained of, and a rough sensation as of dust in the eye; the conjunctiva is seen to be congested, and purulent secretion may be formed. Conjunctivitis is a frequent symptom in arsenical poisoning, and Dr. Taylor describes "tumid, everted lids and painful vision" in patients affected by arsenical papers, etc. (Ophth. Hosp. Rep., 1859, and B. M. J., ii., 1871).

Glandular System. — Under small doses of arsenic the secretions are increased, especially of those glands by which the drug is eliminated. Increase of quantity of the saliva is exceptional in acute poisoning, but occurs when absorption takes place slowly and gradually. The bile, the intestinal secretions, and, generally speaking, the urine are augmented under its use; and if there be no diuresis the perspiration is commonly stimulated, and arsenic can be detected in it (Köhler, Handbuch, p. 724). Hoffmann, Glauber, Agricola, and Pott have even recommended arsenic for a diaphoretic effect, and I have myself sometimes observed this from it.

Osseous System.—Struck by Wegner's observations on bone-changes under phosphorus, and following up the paper of Maas, "On the Influence of Arsenic in Bone-growth, and its Value in Surgical Therapeutics" (1872), Th. Gies has recently published some careful and interesting experiments which well

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illustrate such influence (Archiv f. Exper. Path., etc., Bd. viii., Hft. iii., Dec., 1877). Using at first young rabbits badly nourished, he found that arsenic destroyed them *without* causing bone-change; but having, by careful food, secured for fresh animals apparently more resisting power, the same daily doses (0·005 to 0·002 gramme arsenious acid) continued for nineteen to thirty-four days, seemed to improve their condition, as compared with rabbits from the same litter, and fed in the same manner (but without arsenic): the former were larger, heavier, with clearer skin, and healthier-looking than the latter, and after death the respective bones could be at once distinguished. In the long bones of the arsenic-eaters was a special thick layer (arsen-schichte) of bone between the epiphysis and the shaft; the shaft also was thicker, and in bones, such as the ribs and the vertebræ, the structure was much more dense, and harder to divide, than in normal animals; the new structure was true bone, but the bone-corpuscles and Haversian canals were smaller than the average. Comparative experiments were made with many rabbits, cocks, and pigs, and in such manner as to leave no doubt whatever, that increased growth and condensation of bony tissue were traceable to the action of arsenic. In old animals, where epiphyseal growth had ceased, increase of thickness of bones occurred: on the other hand, if the doses were increased beyond a certain point, resorption of bone occurred, and symptoms of poisoning set in. Bones purposely fractured had not united under the treatment, for their small size made it impossible to keep them in position, but a false joint formed, and much callus was round the broken ends; there was fatty degeneration of all internal organs. Gies does not adopt Wegner's view of increased stimulus given to bone-formation, but rather that of Cunze and Lolliot, that arsenic diminishes tissue-change, especially as regards carbo-hydrates, and hence follow increased deposit and insufficient removal of organic particles.

Genital System.—This system often shares in the general stimulation and irritation induced by small doses of arsenic, as has been noticed in the arsenic eaters of Styria, and in experiments on animals. Gies especially remarked it in the cocks used for his observations on bone-growth (loc. cit.). Clinically, Prof. Charcot was led in two cases to a contrary conclusion, but

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Devergie showed that this could not be sustained, and that stimulation to some extent was not unusual (Bull. de Thérap., 1864); this, however, is not such as to preclude the medicinal use of the drug, and it finds its place in the treatment of amenorrhœa.

In *arsenical poisoning*, inflammation of the genitals has been said to occur (Hunt), and certainly much irritation of them has been present, especially in women; but it would seem to be connected rather with the general irritation of mucous membrane than with these special organs. The young of animals subjected to an arsenical course were born dead, but fully developed; their birth was delayed rather than premature (Th. Gies, loc. cit.), and no markedly injurious effect can be traced on the uterus. In many instances of arsenic being taken by pregnant women, even when with fatal results, abortion has not occurred (Guy's Reports, vol. vii.).

Urinary System.—The urine is commonly increased in quantity for a time under small doses, but with their continuance renal irritation may be induced, so that the secretion is lessened, and elimination of the drug impeded. Hence it is an important practical point to examine the urinary condition during arsenical treatment, and to use, if necessary, alkaline diuretics. Lolliot traced hæmaturia and albuminuria to arsenic, and in a case of phthisis, carefully recorded by Dr. Weir Mitchell, albuminous urine was induced by 4 to 12 min. of Fowler's solution given daily for a few weeks; anasarca also set in, and these conditions ceased and then recurred concurrently with omitting and resuming the medicine (New York Med. Journ., vol. i.). After poisonous doses the urine, though at first it may be passed too often, soon becomes scanty, and its evacuation causes scalding pain and tenesmus; it may contain blood, albumen, and casts, and sooner or later becomes suppressed; urethritis has been already mentioned.

Urinary Excretion in Relation to Tissue-change.—The estimation of urea and other constituents of the urine furnishes important evidence as to the influence of arsenic upon general nutrition and tissue-change, for it is clear that if the principal urinary ingredients are increased under its use, tissue-changes must be going on rapidly, and *vice versâ*. There has been some

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contradiction between observers on these points. Sabelin recorded *increased* excretion of urea under arsenic (from 12 to 28 gr.); also marked increase in the chlorides and earthy phosphates, and proportionate diminution of uric acid,—an incompletely oxidized product (hence G. Sée argued that the drug favoured oxidation and promoted metamorphosis (Nouv. Dict., Art. Asthme)—he has, however, himself since withdrawn these views). Fokker published two analyses showing a slight increase of urea after 0·01-gramme doses (Schmidt's Jahrb., Bd. clviii.), and Gaethgens recorded the same in two dogs taking soda arseniate; also decidedly increased tissue-change under toxic doses (Centralblatt f. Med., 1875, No. 32, s. 529, and 1876, No. 47, s. 833). Binz and Schulz, relying upon these observations, and noting also that hypodermic injection of arsenious acid did not produce a local caustic effect but inflammation in distant organs—*e.g.*, the stomach—have recently argued that "this substance, in contact with living protoplasm, acts in the tissues as an oxidizing agent or carrier from one albuminous molecule to another, being converted during this process into arsenic acid, then reduced, again oxidized, and again reduced" (Centralblatt f. Med., ii., 1879, Med. Times, i., 1879). But I think the evidence insufficient for the conclusion, and all observations upon fasting animals are open to the fallacy that *urea may be increased by the fasting*, and consequent absorption of fat (Forster, Zeitschrift für Biologie, xi., s. 522). The dogs utilized by Gaethgens were kept many days on water only, and a careful examination of the whole question leads to the conclusion that the "tissue-change of inanition" is almost surely the explanation of what he attributed to arsenic (F. A. Falck, Archiv f. Exper. Path., Aug., 1877, Bd. vii.). Von Böck attributed any change he could observe to the effect of fasting (Zeitschrift für Biologie, vii., s. 418-432), and held that arsenic acid in ordinary doses exerted no essential influence on tissue-change.

Others have concluded positively that it *lessens* excretion and change. Thus Lolliot, in a careful thesis, records many observations and analyses, from which he makes evident a *diminution* of urea and carbonic acid under arsenic; he asserts, also, that it lowers temperature, and is a "médicament d'épargne"—it lessens the activity both of nutrition and denutrition (Etude

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Physiol. de l'Arsenic, Paris, 1868). Köhler classes it with tea, coffee, cocoa, as "sparmittel"—diminishing oxidation processes (Handbuch der Physiol. Therap., 1876). In recent experiments by Dr. Tamassia (Pavia), toxic doses of white arsenic given to animals, progressively lowered temperature up to, and after death (Med. Record, Jan., 1878). Animals accustomed to an arsenical ration became pyrexial and emaciated on its withdrawal, implying that some moderating power had been removed. There is still, however, a discrepancy in the observations on temperature; Harless reported a slight rise from small doses, and Billroth, gradually increasing the dose to 40 min. daily in a case of asthma, reported a febrile access in the evenings up to 101° F. (Wiener Woch., 1871, No. 44).

Schmidt and Brettschneider found the excretion of urea and of carbonic acid under arsenic diminished 20 to 40 per cent.; phosphates also diminished. Schmidt and Stürzwage likewise report diminution of carbonic acid and urea in rabbits under minute doses (Schmidt's Jahrb., Bd. clviii., pp. 13–15), and Rabuteau states that the elimination of urea in a dog was lessened for three weeks after a few doses of arsenious acid, at one time as much as 60 per cent.; he attributes its effect in lessening tissue-change to an action on the blood-corpuscles.

I conclude that although some contradiction exists on this point between good authorities, yet the balance of recent evidence points to *lessened excretion*, and consequently to *lessened tissue-change* as an effect of arsenic.

Acute and Chronic Poisoning.—Although not here concerned with cases of poisoning further than as they illustrate physiological action, we may note that if death occurs from large doses of several drachms, and in the course of a few hours, it is generally from *cardiac palsy*, and is preceded by excessive prostation and fainting. If 1 or 2 dr. have been taken, and the patient survives two or three days, the symptoms will be mainly those of *severe gastric and intestinal* inflammation, as already described, and the post-mortem appearances will correspond; whilst with doses of 2 to 10 gr., when the patient survives much longer, and yet dies ultimately from the effects, these will be evidenced rather in the *nervous system* (Hunt). If the poisoning be very chronic, and result from continued doses of $\frac{1}{6}$ to $\frac{1}{4}$ gr., a general

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irritation of the system is apparent from the symptoms of erethism or pyrexia with chills, redness of eyes and of orifices of nose and anus, vesication on palms and soles, with dryness of skin and brownish spots, pain in head and joints and abdomen, with vomiting, purging, and gradual marasmus. The soreness of mouth and salivation have sometimes suggested *mercury* as the poisonous agent, and sometimes the general condition has been mistaken for phthisis, or for typhoid. Gaethgens further suggests points of resemblance with diabetes and with phosphorus-poisoning (Centralblatt f. Med., 1875, Bd. xiii., p. 32, Abstract in Schmidt, 1876). An instructive case which, for a time, completely deceived the medical attendants, and yet which reveals exactly the physiological action of arsenic as we have described it—including renal and nerve-symptoms—is that of Mrs. Wooller as collated by Sir R. Christison (Edin. Med. Journ., 1855).

PATHOLOGICAL CHANGES.—In cases of acute poisoning, the principal changes occur in the stomach and intestinal tract; redness and inflammation of these parts may be found within a few hours of administration; ulceration is not uncommon, gangrene and perforation are rare. In exceptional cases no marked redness has appeared, though arsenic has been found in the stomach (Taylor). Under full arsenical influence there is marked tendency to fatty degeneration of all tissues; in acute cases this is preceded by inflammatory change, and according to Dr. Pinkham (Boston) it may be induced within forty-four hours (Med. Times, ii., 1878). Jaundice occurs, and after death, the liver-cells, the renal tubules, and the intestinal glands are found choked with granules and fat-globules, their epithelium being detached or destroyed. Salkowsky found these changes in poisoned animals within three to six days, the glycogenic function of the liver being impaired very early (Virchow's Archiv, Bd. xxxiv.); it is noteworthy that in such cases, the fourth ventricle may be punctured without causing glycosuria. Virchow described a swollen state of Peyer's patches and the solitary glands, with fatty degeneration of epithelium and "rice-water" secretion containing a fungus that had been thought peculiar to cholera (Archiv, Bd. i., 1870). C. Gies has recently given additional evidence of fatty degeneration of

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tissue under continued small doses of arsenic, but notes also that the subcutaneous fat was increased, and the animals gained weight. Increase of fat and of weight have been observed in chronic arsenical poisoning in man (Boston Journ., 1876).

TOLERANCE.—Arsenic-Eating.—Under certain conditions the system may be brought to "tolerate" full, and even toxic doses of arsenic as of some other drugs, without showing the usual physiological effects. To produce such result, it is necessary to begin with very small doses, and increase them by degrees: thus Flandin, giving at first $\frac{1}{6\,5}$ gr. of arsenious acid to animals, gave, after nine months of progressive increase, 15 gr. per diem without poisonous symptoms (quoted by Stillé).

Taylor distinguishes between "*habit*" and "*tolerance*," meaning, by the latter term, only that power of bearing large doses which is shown in certain exceptional states *without any preparation;* thus, opium may be tolerated in tetanus, alcohol in fever, and antimony in pneumonia; and with regard to the ordinary form of tolerance as *induced by habit*, he remarks that it is mainly restricted to products of the vegetable or organic kingdom—as opium, tobacco, ether, strychnia. He doubts whether any human being can obtain *by habit* any real tolerance of such mineral drugs as corrosive sublimate and arsenic; and certainly experiments on the point can never be pushed far in our own experience.

Yet, on the other hand, evidence in the affirmative does exist. I understand that at Whitbeck (Cumberland), the inhabitants habitually use a natural water which contains nearly a grain of arsenic in the gallon, and are remarkably healthy and long-lived (Chemical News, Aug., 1860). Prof. La Rue reports the case of a man who so far accustomed himself to the drug that he could take 3 or 4 gr. "without more effect than cold water" (Boston Med. Surg. Journ., 1866); but the main evidence seems curiously localized in parts of Austria and Styria, nor can it be any longer dismissed as "pure fable" (Christison) or a "Styrian theory" (Taylor), since the reports of Vogt and Tschudi in 1854 (Med. Times, ii., Wiener Med. Woch., No. 28). M. Heisch, a trustworthy witness, has recorded his personal experience to the effect that he took 3 gr. as a daily dose for many years; he began it, when appointed

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director of arsenic works at Salzburg, with the object of protecting himself from the effects of the fumes; he retained good health, but when he attempted to leave off the drug suffered from restlessness, insomnia, faintness, and finally from lung-symptoms (Lancet, 1860). Prof. Schäfer records that $\frac{1}{60}$ to $\frac{1}{10}$ gr. is an initial dose commonly used for the first fortnight, then it is omitted for the same period, and then resumed and gradually increased to 5 gr. or more (Nothnagel, p. 241) —Heisch says that 23 gr. have been taken for a dose. Arsenious acid is the usual form, but sometimes orpiment is substituted. Dr. Maclagan saw doses of several grains swallowed, and he afterwards detected arsenic in the urine (Edin. Med. Journ., 1864); and I have myself learnt from persons at Salzburg that the habit was very common, and have seen men who had taken from 5 to 10 gr. daily for many years, with occasional intermissions, and who looked robust and healthy. Near Harzburg they have the curious custom of regulating their doses by the moon—they gradually increase to the full moon, and then diminish and take purgatives of aloes: some avoid drinking with their dose of arsenic, others avoid fat, and others keep to a farinaceous diet, but the majority eat and drink anything. The practice prevails mostly, if not entirely, amongst the working-classes, but is not confined to men. Its effect is said to be to increase fat and stoutness, and yet to render them more equal to exertion, and especially to mountain-climbing without difficulty of breathing; also to give freshness to the complexion, brightness to the eye, and general vigour to bodily function.[1] It is agreed that much depression and emaciation occur on the withdrawal of the drug from those who are accustomed to it, and although a certain number who commence early to take it continue its use to an advanced age, yet it is said, and we can well believe it, that it does much harm and even proves fatal in an insidious manner to many persons, especially amongst the young. We cannot depend upon securing an indiscriminate

[1] Gubler explains these effects by diminished oxidation and tissue-change (*v.* p. 435), suggesting the connection of muscular fatigue with formation of sarco-lactic acid; he presumes this to be lessened by arsenic alike in thoracic, respiratory, and other muscles. They can therefore work longer, there is less carbonic acid to be discharged by the lung, and less labour or hurry in respiration.

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tolerance of arsenic; nothing of the kind has been reported in this country, but on the contrary many have suffered from a foolish imitation of the Styrian custom.

Effects of Arsenical Wall-Papers, etc.—It is now clearly ascertained, though the knowledge is comparatively recent, that all the serious symptoms already described may be produced in greater or less degree by arsenical emanations from wall-papers and paints, hangings, dresses, ornaments, etc.; and not only from the green colours containing arsenite of copper, and which have long been suspected, but also from red, drab, blue, grey, and enamel papers generally (B. M. J., ii., 1871), and from aniline colours fixed by arsenical mordants in carpets, curtains, etc. (Taylor, On Poisons, 3rd Ed., p. 353). Soon after the earliest observations on the subject, in 1858, Mr. Phillips (the chemist consulted by the Board of Trade) stated that a more than bearable heat would be required to volatilize arsenic, but Fleck has pointed out that the contact of moist organic substances (such as sizing) readily disengages arseniuretted hydrogen from Schweinfurt green (Zeitschrift für Biologie, Bd. viii., 1872), and Hamberg has verified its presence in the air of rooms (Pharm. Journ., Aug., 1874). This gas is a very powerful poison. Gehlen, the chemist, was killed by a small quantity, and in some recent cases it caused severe epistaxis, hæmaturia, and jaundice (Comptes Rendues, 1863, Gaz. de Paris, No. 18, 1873). Usually, however, the injury is done by material particles of arsenical dust (Chevallier, Annales d'Hygiène, vol. xii., p. 49). Some time ago I met with many cases of catarrh, irritation of mucous membrane, etc., which proved to be due to this cause, and I can quite corroborate the observations made by Mr. Clarke, of Bristol (in a careful paper in B. M. J., i., 1873), who finds that in one set of cases dyspepsia, nausea, sore throat, and conjunctivitis are the prominent symptoms, whilst in another nerve-troubles, headache, irritability, prostration, and restlessness are more complained of, though dyspepsia and especially coated tongue are not absent; in a third group the prostration, headache, and nervous excitement simulate a mild typhoid. He records violent sneezing, and also an eruption of eczema and of nasal ulceration as exceptional symptoms, and further points out that a case of ordinary illness may be much aggravated by an arsenical atmosphere, and that some patients

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are much more sensitive to it than others. Arsenic was detected in the secretions of several of Mr. Clarke's patients. The symptoms are generally worse in a damp atmosphere, and in the evening when the room is heated. Dr. Hinds describes "depression, faintness, nausea, and colic," after reading by gaslight in a green-papered room (Med. Times, 1857). Mr. Whitehead reports similar symptoms in a youth every time he occupied a certain bedroom only (B. M. J., 1858).

The real cause of chronic ill-health may be long unsuspected, and a striking case is related of the simulation of various forms of disease in one family for upwards of twelve years before their true cause was discovered in arsenical wall-papers (B. M. J., ii., 1871). Dr. G. Johnson has reported the case of a medical practitioner, in whom chronic dyspepsia, catarrh, cough, and even asthma were due entirely to the same agency (Med. Times, ii., 1874). Similar symptoms have followed, though less frequently, from painted walls, gas-shades, etc. (Basedow, in Month. Retros. Med. Sci., 1849, New Syd. Soc. Year Book, 1860, etc.). Dr. F. Brown (Boston) has reported several interesting and important cases of chronic illness from arsenical paints and wall-papers: he notes that most of the patients had increased in weight (Bost. Med. Surg. Journ., 1876). Some years ago arsenic was purposely used for clarifying candles, and thus serious effects were produced, which still sometimes follow the use of candles coloured green. Arsenical poisoning has occasionally occurred from cigars (New Syd. Soc. Year Book, viii., p. 432), and from green cigar-holders (B. M. J., i., 1879). Mr. Jabez Hogg has drawn special attention to eye-inflammation from arsenical papers and to other illnesses produced by them (Sanitary Record, April, 1879).

SYNERGISTS.—Antimony is the most complete analogue of arsenic, except that the former is a more certain emetic: phosphorus also is allied in action.

The effect of small doses, upon the nervous system especially, is allied to and supported by quinine and by alkaline bromides, whilst the tonic influence of similar doses on the vaso-motor nerves (leading to contraction of vessels, at least

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temporarily) is allied to that of acids, astringents, ergot, and cold applications. Doses sufficient to lessen oxidation and combustion act somewhat like cyanides and other substances which prevent these processes.

ANTAGONISTS — INCOMPATIBLES. — Diffusible stimulants, alcohol, warmth, and, according to Gubler, opium, are the vital antagonists to arsenic. Iron, in the form of hydrated peroxide, magnesia, calcined or as hydrate, lime, animal charcoal, and astringents generally, are chemical or mechanical antidotes. Iron and magnesia have power over arsenic in *solution*, since they precipitate the poison in an insoluble form; with *solid* arsenic "they have no more effect than powdered brick-dust" (Taylor). A mixture of hydrate of magnesia and persulphate of iron is best to use, and the resulting sulphate tends to act on the bowels. The "antidotum arsenici" of the German and other Pharmacopœias contains calcined magnesia 7 parts in 120 of water, solution of persulphate of iron (sp. gr. 1318) 60 parts in 120 of water: the two parts to be kept separately and mixed at the moment of administration. Pure dialysed iron is not antidotal, but according to Mattison becomes serviceable if salt be added to it (Med. Record, 1878), since this precipitates a hydrate.

In cases of poisoning, vomiting should be produced and promoted as early as possible, by ipecacuanha or zinc sulphate: nor is antimony so undesirable as has been stated; many cases have recovered under its use (Morgagni, and Gaz. des Hôp., Aug., 1844, etc.), also after infusion of tobacco (Med. Times, i., 1857). Milk and demulcent drinks containing, *e.g.*, eggs, flour, or fats, should be given, and large frequent doses of any of the antidotes named, a tablespoonful of the iron compound every five to ten minutes (B. M. J., ii., 1863).

THERAPEUTICAL ACTION. — *External.* — Parasitic Diseases.—In scabies, and in phtheiriasis, arsenic has sometimes been used, and a lotion containing a small proportion[1]

[1] Arsenious acid 1 part, carbonate potash 20 parts, soap spirit 200 parts, water 2,000 parts. (Soap spirit is made with equal parts of soft soap and spirit of wine.)

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with soft soap and spirit of wine has been much commended: it is painful in application and has not seemed to me so good as other remedies; neither is the use of this substance free from danger, for an arsenical salve applied for scabies has produced poisonous effects.

For *ascarides* Trousseau recommended an injection of $\frac{1}{5}$ gr. of white arsenic in 4 oz. of water; it is not often used, but would probably be effective. M. Boudin used the same remedy in larger doses, but it is unnecessarily dangerous.

Lupus—Cancer.—In these maladies the caustic action of arsenic is often extremely valuable, and the powdered drug may be used sufficiently strong to destroy diseased tissue without affecting the adjacent sound skin. For chronic superficial lupus, especially of the face, Hebra recommends "Cosme's paste," containing 20 gr. of arsenious acid and 60 gr. of cinnabar in 1 oz. of rose ointment (cold cream): this is spread on linen, and applied firmly for twenty-four hours, and then renewed for the same period, a third application being made if required. I have often used this with good results; at first there is little change produced, but by the second day the growth turns grey, and by the third day commences to slough, and may be separated in a poultice. Pain and œdema may occur, but can be relieved by sedatives and warm applications. Amongst many hundred cases thus treated, no poisonous symptoms have been reported.

In *epithelial cancer* arsenic has long been used. Rousselot combined it with cinnabar, and Dupuytren with calomel, and Mr. Marsden has written in praise of its association with an equal part of mucilage. The paste commonly known in Ireland by the name of Miss Plunkett's is prepared with arsenious acid, sulphur, and two species of ranunculus: it often acts powerfully.

As already stated, caution is required in the external use of arsenic: not that it should be applied in a more diluted form, for then its absorption would be even more probable, but only a limited area—not more than one square inch—should be covered at one time. Dr. Walshe has specially insisted that its use should be restricted to superficial cancer. From the internal administration of arsenic I have had good results in epithelioma (*v.* p. 469).

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Dental Surgery.—Arsenious acid is in daily use for destroying the nerve-filaments in a tooth-pulp before filling the cavity, and it is still considered one of the best agents for the purpose. It is true that violent symptoms have sometimes followed its use, which always needs caution: still osteitis and its accompanying pain might occur after any destructive application, and we may fairly consider that $\frac{1}{10}$ gr., especially when combined, as it usually is, with a little morphia, is free from any serious risk of arsenical irritation.

Rheumatic Gout.—Baths containing from 15 to 30 gr. of arseniate of soda, with a few ounces of the carbonate of soda, have been well spoken of by Dr. Guéneau de Mussy, as relieving both the pain and the deformity consequent upon rheumatic arthritis. There is some evidence in favour of the internal use of the remedy for this malady (*v.* p. 450).

THERAPEUTICAL ACTION.—*Internal.*—The therapeutical powers of arsenic, which are many and various, may be traced along the same lines as its physiological action, and without implying any definite limits as to the pathology of the undermentioned diseases, we may, for the sake of clearness, arrange them in four groups for consideration in detail:—(*a*) General or blood-diseases, such as intermittent fever, phthisis, struma, lymphoma, anæmia, chronic rheumatism, diabetes; (*b*) more specially nerve-disorders, neuralgias, asthma, chorea, tremor; (*c*) disorders connected mainly with capillary congestion, cerebral, renal, uterine, or cutaneous; (*d*) disorders affecting chiefly mucous membranes, coryza, chronic bronchitis, dyspepsia, gastric catarrh, vomiting, diarrhœa, English cholera, gastric ulcer.

Intermittent Fever—Ague.—Long used as an empirical remedy for ague, in the East, its more scientific employment dates from Slevogt, of Jena, in 1700.[1] Condemned by Baron Störck, it was re-introduced by Dr. Fowler, of Stafford, in 1786,

[1] Of the older writers on this subject, Melchior Frick, and the two Plencitz, of Vienna, deserve mention. The former says—"Experientia nos docebit, arsenicum in febribus intermittentibus adhibitum omnes eas dotes possidere, quibus optima remedia prædita esse debeat" (Paradoxa de Venenis, 1710). Of the practice of the latter at the Orphans' Asylum, Harless reports—"Ejusque (arsenici) usu in millenis fere febrium intermittentium casibus, raro frustratos fuisse affirmant."

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after experience of the effects of a "patent ague drop" which contained it; and again condemned by Broussais. Its value was finally re-established by Boudin, in 1842, after a prolonged experience in Algeria (On Intermittent Fevers, Paris, 1842). The English physician reported several hundred, but M. Boudin, 4,000 cases, almost all successful. The former was accustomed to press the remedy to its "operative" or physiological effects; the latter aimed at inducing "tolerance," commencing with fractional doses every quarter-hour, so as to introduce as much as possible into the blood, and to "substitute an arsenical for a paludal saturation." The names of Sistach, Millet, Fremy, and Isnard are associated also with records of large numbers of successful cases, whilst opposite experiences may be found in the works of Gintrac, Oesterlen, and G. Sée.

In 1860, Mr. J. Turner reported such favourable results with ½-dr. doses of Fowler's solution, given every second hour for four or five doses, that the Director-General recommended the plan to army officers (Med. Times, ii., 1871), and Dr. Chappell supported it with an account of 80 cures out of 140 cases (Med. Times, i., 1861). The same dose was used by Dr. Broderick, but not without sickness (Brit. and For. Rev., 1866). These observers found, as did Fowler, Rayer, and others, that much better results in curing ague were obtained with large doses, as of 30 to 40 drops, than with ordinary, full, or unusual doses up to 20 drops; but Sistach and others observed that as soon as the fever ceased, the system ceased to "tolerate" such quantities, and there is always a possibility of the remedy doing harm. Quite recently has been recorded the case of a physician, aged fifty, who took 12 drops of Fowler's solution twice daily for about three months with apparent benefit to the intermittent, but he got diminished secretion of urine, colic, tenesmus, weak heart, etc., and died rather suddenly with vomiting and syncope; his attendant (in South America) traced his symptoms to arsenic, and Dr. A. S. Taylor concurs. It must be said, however, that an ordinary cerebral attack—*i.e.*, independent of arsenic—is not excluded by the history given (Med. Record, Feb., 1879).

We cannot doubt that arsenic, suitably administered, is an effective remedy for ague, but on comparing it with quinine,

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and allowing for a percentage of spontaneous recoveries from mild attacks, we conclude that the latter remedy is still to be preferred for severe and acute cases, and in "pernicious" or "malignant" forms; also it acts better usually in tertian ague. When, however, it has failed to cure such cases even in excessive or long-continued doses, or when the malady is of moderate severity, subacute or chronic, especially of quartan type and accompanied with marked œdema and prostration, then arsenic is specially indicated. The element of risk may be much lessened by careful attention to the urine and the general symptoms.

Splenic or hepatic hypertrophy may be another indication for it, as Boudin suggested. It is good in malarious cachexia (when quinine often renders but little service), also when jaundice is present; further it has some prophylactic power, and assists in preventing relapse.

I have records of nineteen cases of severe chronic agué of the quartan type, all successfully treated by arsenic. Most of the patients were Americans who had taken quinine very largely, being in the habit of carrying it in their pockets and taking from 5 to 20 gr. whenever they fancied an attack was impending. Many of them had clean, red, irritable tongues, and were suffering from œdema or anæmia; in most of them the spleen was enlarged, and in some the liver. I prescribed the liquor arsenicalis in 5 to 10-min. doses thrice daily, and the result of this treatment was uniformly good. Both quinine and arsenic have been credited with an "anti-zymotic" power of destroying malarial germs in the blood. As regards the prevention of relapse, Hirtz, judging from 120 cases, found quinine and arsenic nearly equal; probably the best results may be obtained by a judicious combination of them both, full doses of the former being given to ward off an impending paroxysm, and arsenic in the intervals: this mode of treatment I have frequently adopted with success. Prof. Gubler uses arsenic in ague as a sedative, and "indirect reconstituent," and connects its anti-relapse efficacy with its permanent deposition in the tissues.

Phthisis.—For the employment of arsenic in chest-diseases we may go back as far as Dioscorides, who states that "sanda-

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rach" (probably the sulphuret) "is given to patients suffering with lung-suppuration, and mixed with resin is inhaled in vapour for obstinate cough." Dr. Beddoes used it early in this century, and recently the value of the drug in certain stages of tubercular phthisis has attracted renewed attention. Hérard and Moutard-Martin have especially recorded good results from it in relieving the lung-congestion and the general pyrexia of early stages; at the same time the latter physician observes that it is most efficacious when phthisis assumes a *slow* torpid course, acute tuberculosis not being modified by it. "It has a reconstituting action, and modifies secondarily the pulmonary lesion" in suitable cases (Lancet, i., 1868).

Before suppuration of tubercular deposits has taken place, I have found arsenical solution in 2 or 3-min. doses, three times daily, give particularly good results; it is well to combine it with a course of cod-liver oil and change of climate, and it should be continued for weeks or even months if possible. I agree with the account given by Isnard (which is still more favourable), for he found it relieve profuse sweatings, improve appetite, and promote in some favourable cases not only healing of cavities but absorption of tubercle (Bull. de Thérap., t. lxxvii.). It controls diarrhœa in these cases in a very marked way.

Cersoy traces to arsenic an effect which has been also attributed to it in bronchitis, and which really accords with what we know of its physiological action—viz., the lessening of congestion both in the bronchial mucous membrane and in peri-tubercular lung-tissue; thus he finds that it benefits hæmoptysis (Gaz. des Hôp., 1869). Prof. Stillé thinks it probable that any benefit conferred in phthisis is due to an influence upon the accompanying bronchitis.

Massart is almost alone in his recommendation of an *arseniate of gold*, which, in doses of $\frac{1}{10}$ to $\frac{1}{8}$ gr., he found useful even in advanced cases (Rev. de Thérap., 1860, p. 21). The general opinion of French observers, however, would restrict the value of arsenic to early stages, or to the relief of certain symptoms: thus Nouat agrees as to the good results of $\frac{1}{70}$ to $\frac{1}{30}$-gr. doses given early in the malady, and finds that in later stages, especially in the cases mostly seen in hospital practice, benefit is exceptional (Lancet, i., 1870); and Trousseau, whilst recording

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improvement as to diarrhœa, hectic, expectoration, and cough, does not speak of cures, but of the gradual development of the malady and the formation of fresh tubercle. He prescribed cigarettes containing arseniate of soda, and pilules of arsenious acid.

I do not find many English observations on this subject, nor has this medication for phthisis been generally adopted amongst us. Dr. Williams says, "I have tried it only to a limited extent. . . . . It has only seemed to be useful in chronic cases with asthmatic or cutaneous complication, but well deserves further investigation" (Pulmonary Consumption, p. 362). Dr. Ringer suggests that allowance must be made for a natural improvement in some forms of phthisis, but has himself seen instances of recovery under its use "in children with general tuberculosis," and "in adults suffering from subacute and chronic forms." He corroborates also, to some extent, the statement that it will reduce temperature (Handbook). Dr. Sanger reports, from the convalescent hospital at Seaford, favourable results in a large number of phthisical patients to whom he gave 5-min. doses of Fowler's solution, but he generally combined it with iron or hyposulphites (Lancet, i., 1869). Dr. Leared based a favourable opinion upon observation of nine cases, but finds the remedy "trying to the digestive system" (Med. Times, i., 1863), and this I believe to be a very common result owing to the dose prescribed being too large. Dr. Bartholow, without offering detailed evidence, affirms that "we have no single drug of equal utility in the chronic forms of phthisis, but it is not serviceable in caseous pneumonia . . . . neither is it beneficial when much hectic is present with rapid disintegration of pulmonary tissues."

Struma—Strumous Ophthalmia.—In chronic cases of glandular enlargement, pallor, and anæmia, occurring in subjects with the ordinary evidences of struma, arseniate of soda is often beneficial; it improves appetite and colour, seeming to stimulate the lymphatic and arterial systems. I have frequently known Fowler's solution prove serviceable in strumous *ophthalmia*, giving relief to the redness and swelling of lids, as well as to conjunctival congestion and excessive secretion. It has seemed also to help in cicatrizing ulcers, and in diminishing the exudation which would produce leucoma. Mr. Oglesby

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speaks of its special value in that form of strumous ophthalmia which is accompanied by herpes (Practitioner, vol. ii.).

Strumous Cachexia—Lymphoma.—Prof. Bouchut restricted the value of arsenic in glandular disease to cases where this was superficial and limited, and where cachexia was not present, but later experience has proved the remedy to be more generally useful than he believed. I have seen it of much service, especially when combined with iron, in relieving cachexia, and Billroth has recorded a remarkable case—that of a woman, aged forty, in whom the cervical, axillary, and other glands, as well as the spleen, were affected, and who recovered under Fowler's solution, taking 5 to 20 drops for a dose. Billroth's observations have not been often repeated, but have been recently supported by Dr. Winiwarter. He records good results in cases of malignant lymphoma, or Hodgkins' disease, a malady limited to lymphatic structures, and to be distinguished from a sarcoma commencing in the glands, and spreading from thence. In the latter condition, arsenic has no influence: neither is "Hodgkins' disease" to be confounded with scrofula, for there is no tendency to suppuration; nor with leukæmia, for there is no increase of white corpuscles. The malady referred to occurs in strong young persons, often begins in the cervical glands, which enlarge separately, and it is fatal if left untreated; it has been observed to follow intermittent fever. Under the use of arsenic, continued for three or four months or more, and also injected into the tumours, they have disappeared, at least for several years, and the patients have become convalescent. It is recommended to begin with 5 min. of Fowler's solution and 5 min. of tinct. ferri night and morning, cautiously increasing the dose up to 30 to 40 min., or to the production of physiological effects (Stricker's Jahrb., 1877, part ii.).

Chlorosis.—In this disease arsenic often acts particularly well, and has been strongly recommended by Isnard.

Progressive Pernicious Anæmia.—The remarkable and serious malady now known under this name, and which was first described by Dr. Addison as "idiopathic anæmia," has proved sometimes amenable to arsenic. It occurs often, without appreciable cause, about or beyond middle age, the patient becoming blanched and waxy-looking, sometimes jaundiced, and

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suffering later from œdema, dyspnœa, giddiness, and coldness. The blood is found to be dull-red in colour, and the red corpuscles to be diminished and altered; retinal and other hæmorrhage may occur, also occasional attacks of vomiting and diarrhœa. The patient remains, or becomes, fat rather than emaciated, yet the disease has usually ended fatally by exhaustion and collapse in spite of iron and food, etc. Dr. Bramwell has recently recorded a typical case, which was carefully treated in hospital for three weeks with full doses of quinine and iron, and later phosphorized cod-liver oil, and yet steadily got worse until 2 min. of liquor arsenicalis were given thrice daily, the other remedies being stopped. The dose was gradually increased to 16 min. thrice daily, and "the after-progress of the case may be described as one of slow but uninterrupted improvement." In a month's time he was able to attend as an out-patient, and continuing to take arsenic considered himself well, and resumed work. His colour improved, cardiac murmurs disappeared, and the condition of the blood was found to be normal (Med. Times, ii., 1877). Such a case, in conjunction with others, offers much encouragement in the use of the remedy, and serves to illustrate further its alliance with phosphorus, which drug has also proved useful in some similar cases (*v.* p. 72).

Dr. Lockie has lately published illustrations of the value of arsenic as a "blood and cardiac tonic in anæmia" (B. M. J., ii., 1878). Dr. M. Finney has recently reported three well-marked cases of "pernicious anæmia," two of which recovered under arsenic, and he calls it "one of our surest tonics to the blood-making organs" (B. M. J., i., 1880). Dr. Withers Moore informs me that in a similar case (idiopathic anæmia), under his care at the Sussex County Hospital, arsenic also proved of service. The patient, a woman, aged thirty-two, showed characteristic symptoms of the malady nine months after a bad confinement, and after frequent epistaxis: she was extremely pale and feeble; the red corpuscles of the blood were few, small, and altered in shape, the white corpuscles not increased in number. For the first three months of her stay in hospital iron was tried in various forms without any benefit whatever; for the last two months she got 3 min. of Fowler's solution thrice daily, and ultimately left convalescent. The case was a typical and

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severe one, with occasional pyrexial attacks, raising the temperature to 104° F., and even, on one occasion, to 106° F. These attacks were controlled by full doses of quinine, but excepting this, arsenic was the only medicinal agent used during the stage of recovery.

Chronic Rheumatism—Chronic Rheumatic Arthritis.—In the condition now designated by the latter term, the value of arsenic has been frequently shown since its recommendation by Haygarth, and the elder Bardsley in Manchester (Medical Reports, p. 32). I quite agree with the latter physician in his opinion that the remedy promises well in cases where the vital powers are diminished, and the ends of the bones, the periosteum, capsules, and ligaments are swollen; under the continued use of the drug I have known the joints return to their natural size. Sir R. Christison records a similar experience in cases of "nodosity of joints," and Dr. W. Begbie describes fully the case of a man with swellings of the small joints of hands and feet, very painful, especially at night and in changeable weather, and almost preventing any movement. The patient had received no benefit from a long trial of many remedies, but under a course of Fowler's solution recovered the use of the joints, and was able to resume his work. Dr. Fuller speaks highly of the remedy in "chronic rheumatism," and especially in rheumatic arthritis, when the skin is dry and inactive, and the patient chilly.

Snake-bite.—Amongst blood-diseases we may include this form of blood-poisoning, and although it is difficult to credit arsenic with efficacy in such cases, we must admit not only a long tradition in its favour in India (*v.* Dr. Russell's History of Indian Serpents), but some amount of clinical evidence. A compound of white arsenic with black pepper and native herbs is the popular form, known as "Tanjore pill," but Mr. Ireland used 2-dr. doses of the liquor arsenicalis with 10 min. of tinct. opii every half-hour for four successive hours in five cases, and all of them recovered, although other patients died from similar bites (Med.-Chir. Trans., ii., p. 393). No doubt, the system, under abnormal influences, can tolerate larger doses than in its healthy state.

Diabetes.—Like most other medicines, arsenic has been

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tried in this malady, and it has received commendation. Dr. B. W. Foster says that he has seen it act well in improving nutrition and lessening thirst, but not in diminishing the excretion of sugar; hence, he considers it acts mainly by saving the waste of albuminous tissues (Clinical Medicine, p. 208). Dr. Bartholow finds it beneficial in thin subjects with defective assimilating power, but not in the "stout subjects" who suffer from boils and carbuncles. I have frequently prescribed it in both stout and thin subjects, with good results, but as a rule it only acts as a palliative, checking the sudden emaciation and prostration and relieving the excessive thirst and dryness of mouth. In several cases it lessened for a considerable time the quantity of urine, and in some instances appeared to diminish the sugar; it certainly in nearly all cases improved digestion.

Neuralgia.—Arsenic holds a chief place amongst remedies for neuralgia. Dr. Fowler's original reports contain several conclusive cases, although their relief seems somewhat counterbalanced by the gastric symptoms, which he did not scruple to produce. Maculloch, in a well-known "Treatise on Malaria," speaks highly of arsenic in confirmed neuralgia; and Romberg, a still higher authority, notes its value especially in facial neuralgia, and in forms connected with uterine or ovarian disease. Anæmia is also an indication for its use, and full doses are necessary. Amongst modern French observers, Isnard reports many cures of various typical neuralgiæ, and of ordinary neuralgic pain (De l'Arsenic dans la Pathologie du Système Nerveux). M. Boudin found it invariably succeed in periodic—probably malarial—forms, and M. Cahen has published sixty-five successive cases of almost uniformly good result (Archives de Méd., 1863). Borella devotes a long chapter of his work in praise of arsenic, to its value in nerve-disorders (Brussels, 1866). Of modern German writings on the subject we may quote Erb, who adopts mainly the views of Isnard, considering the remedy as "a neurosthenic tonic," with the power of restoring order to disturbed action. He places it in the first rank amongst specific remedies, not only in recent and periodic cases, but also in chronic forms of purely idiopathic neuralgia. In the facial variety and in sciatica, he endorses its high reputation, but in

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the latter affection places its value below that of turpentine (Ziemssen's Cyclopædia). In the treatment of sciatica, arsenic is most suitable when the pain is deep-seated, worst at night, but with occasional marked intermissions, and temporarily relieved by hot applications.

Sir Thomas Watson notes the great use of the drug in hemicrania or migraine (Op. cit., i., p. 733), and successful results in various cases from full doses of Fowler's solution were published by Mr. Thomas Turner, of Manchester (Med. Times, ii., 1861). Dr. Anstie, in his Treatise on Neuralgia, speaks of arsenic as "one of the most powerful weapons in the physician's hands," "likely to act best in affections of the fifth and of the vagus nerves, but probably the most generally effective remedy in almost any given case." He looked upon it as calculated to improve the quality of the blood, to stimulate the nerve-system, and oppose periodic (disordered) action. The same physician also pointed out the connection and frequent interdependence of gastralgia, angina pectoris, and asthma, as neuroses of different branches of the vagus, and he illustrated this connection by the history of families in which these affections occurred in alternate generations. From my own extensive trial of arsenical medication in neuralgiæ, and especially of the fifth pair of nerves, I also conclude it to be almost our best remedy, particularly, as in my own person, when the pain felt is of burning stinging character, and when the attack is connected with miasmatic influence.

Gastralgia is a term properly restricted to painful affections of the stomach unconnected with organic disease or inflammation, or even with ordinary dyspepsia. Such cases are not very frequent nor very easy of diagnosis, but occur especially in females during youth, and at the climacteric period, and are accompanied with other evidences of impaired nerve-power: sometimes they are reflex (being connected with uterine derangement), and sometimes malarial (Niemeyer). Trousseau describes attacks dependent on exhaustion, and Budd on alcoholism. The nerve-character is evident when, as in Dr. Anstie's cases, the malady alternates with attacks of asthma, and Tessier (Journ. de Méd. de Lyon, 1848) and Anstie agree in estimating highly the value of arsenic in such cases. Dr. Clifford Allbutt speaks of gastralgia as readily distinguishable

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from dyspepsia, and describes sudden violent pain in the gastric region and back, and another form less severe and more gradual in onset, and irregular as to time, and unconnected with eating (Liverpool and Manchester Reports, 1873). Dr. Leared also restricts the term to a nerve-disorder with cramp-like, fixed or diffused pain, coming at irregular intervals, often at night, accompanied by prostration, followed by bilious vomiting, and occurring generally in middle-aged persons from mental anxiety (B. M. J., 1867). Such cases furnish a special indication for arsenic, and Allbutt says it is, for such, the "king of remedies," only I would interpret "gastralgia" in a wider sense, and without attempting to diagnose it rigorously from dyspepsia, would include under the term many forms of painful stomach-disorder, not inflammatory nor organic. In this sense it is used by Barras (Traité sur les Gastralgies) and other French writers, and a reference to the observers I have named will show that, in their cases, such symptoms as flatulence, vomiting, and pain increased by food, were often present, and although the tongue might be clean, and certain dyspeptic symptoms absent for a time, yet they would readily occur, and to restrict the use of the remedy to purely nervous attacks is needlessly to limit its value: we shall see, in fact, that in gastric catarrh it is an excellent medicine.

The following is one of many cases of climacteric gastralgia, complicated with dyspepsia at times, and relieved by arsenic. Mrs. S., aged forty-three, auburn hair, thin, describes very acute pain in upper front chest, and sometimes in the back about the second dorsal vertebra and interscapular region, almost constant, sometimes easier after food, sometimes worse: no vomiting, pyrosis, or hæmatemesis: no physical signs in the chest, no evident hepatic disease, and bowels regular. Pulse 64. No heart or lung-complication. Youngest child is five years old. Menstruation lately irregular and profuse; has some prolapsus and back-pain, distinct from her gastric pain. Nursed her husband anxiously for two years, during which time the pain first came on, and is now often brought on and always aggravated by mental worry, of which she has much. The pain is generally worst on waking about 2 a.m.; gets better after breakfast, and worse again in the evening: it is sometimes

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referred to the epigastrium and left shoulder, and described as "like a hot bar pressing," or "like a hand gripping." Arsenic relieved the pain more effectively than any other remedy tried, and although during attacks of painful digestion nux vomica given before food did much good, according to the patient's own statement, the steady use of arsenical solution was always the most effective.

Angina Pectoris.—This malady, even if primarily dependent on calcareous or other degeneration, is mainly a neurosis, and nearly 100 years ago was successfully treated with arsenious acid by Alexander. Philipp and others record very striking benefit in cases that had been rebellious to quinine (Syd. Soc. Year Book, 1865-66), and I can fully bear out Dr. Anstie's testimony to the great relief given by arsenic to patients suddenly attacked with spasmodic pain, embarrassed heart-action, and sense of impending death: he found the medicine reduce the severe attacks to little more than a tightness of the chest, and it availed most in anæmic patients, suffering from overwork and anxiety. (Reference may also be made to cases in Berlin. Klin. Woch., 1865, and Archives Gén., 1863.)

Spasmodic Asthma—Asthma Nervosum.—In this, the third of the trio of vagus neuroses, Dr. Anstie also records good results, but others had preceded him in this observation. We have already noted its improving the breathing-power of mountaineers, and this had suggested to Kappel its use in asthma. Rilliet speaks highly of it (Bull. Med. du Nord, 1863), and also Trousseau, who used it partly in cigarette (Bulletin, 1861). Dr. Leared recommends a form of cigarette containing ½ gr. of arsenic with a little nitre (Lancet, i., 1863). Dr. Thorowgood, whilst laying stress on the frequent gastric causation of asthma, and its special treatment, has found arsenic useful in gouty and rheumatic cases, and Riegel notes its value in preventing relapses in "bronchial asthma," and in the form which occurs alternately with some cutaneous diseases, known as "herpetic asthma" (Ziemssen's Cyclopædia, iv., p. 582). Dr. Berkart seems to attribute any good effect more to improving the nutrition, appetite, and digestion, and to negative any specific virtues (On Asthma,

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1879). One method of its application is by spray, which has been used with much success by Wistinghausen (Petersburgh Med. Zeits., 1862), and more recently by Dr. Wahltuch, of Manchester: the latter used arseniates of potash, soda, or ammonia in spray containing $\frac{1}{6}$ to $\frac{1}{2}$ gr. at first twice daily, and by degrees less frequently; his excellent results were, however, rendered less certain for clinical purposes by the concurrent use of galvanism and other remedies (B. M. J., ii., 1877).

Martelli has recently reported immediate relief to an asthmatic paroxysm from the hypodermic injection of Fowler's solution, (1 part to 2 of water): the cure was complete after 2 dr. used at intervals in divided doses in this manner (Med. Record, 1878). Arsenic acts best in simple cases of idiopathic or spasmodic asthma of neurotic origin: but it has done well in cases dependent on bronchitis, emphysema, or cardiac disease. In cases due to compression of air-tubes by enlarged glands it may be carefully tried (Berkart). The solution should be administered in 5-min. doses, three or four times daily, during the intervals between the attacks, and should be persevered with for many weeks, and in some instances for months, but the dose under these circumstances should be decreased. For upwards of twenty years I have used it in these cases with unmistakable success.

Chorea.—From the time of Girdlestone—1806 (London Med. Phys. Journ.)—there has been a large accumulation of evidence as to the value of arsenic in chorea. Reese, of New York, in 1840, describes cures in 200 children under 6 to 8-min. doses of Fowler's solution twice daily. Rayer corroborates his results (Union Méd., 1847). Romberg calls it "the foremost remedy," when given in sufficient doses (Klin. Ergebnisse, 1856), and records severe cases—one of eight years' duration, rebellious to many other medicines, but cured in two months by arsenic; and another patient had been unable for six months to stand or speak, having such violent choreic movements, yet recovered after two months' of treatment with 4 min. of Fowler's solution thrice daily. The well-known names of Aran, Henoch, Steiner, and Barthez may also be cited as authorities in the same direction; and continental work with

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regard to it is fully summarized in the thesis of M. Gellé (Hôpital des Enfants, Paris, 1860). He quotes cases where improvement was manifest within eight days, three days, and even forty-eight and thirty-six hours respectively, but concludes that from five to eight days is an average period. He gives also several cases equal in severity to those of Romberg, and expresses similar conclusions—viz., that some failures of the remedy may be expected in neurotic, sanguineous subjects, but very great success in the lymphatic, chlorotic, and cachectic. M. Aran urges the rapid attainment of a full dose rather than a long-continued small one (Syd. Soc. Year Book, 1859). Dr. Steiner, on the other hand, commences with 1 min., and considers 8 min. should be the maximum daily dose: within fourteen days he expects improvement.

Amongst English observers there is a large preponderance, though by no means a consensus of opinion in favour of arsenic as the best remedy for chorea. Gregory, Babington, and many others have all writen to this effect. Dr. Radcliffe fully agrees as to the efficacy of the medicine, but having been obliged sometimes to discontinue it on account of gastric disturbance, he adopted its hypodermic use, and in some cases, especially of localized choreic action, with signal benefit; thus, in a woman in whom the neck-muscles were affected, and who was not relieved by a long trial of sedatives, 1 to 12 min. of Fowler's solution were injected locally, and before the fourth injection, improvement had taken place. He recommends dilution with half water; in some cases he has preferred the endermic use of the remedy on a blistered surface (Reynolds' System, vol. ii.). Schmidt has also practised hypodermic injection with success (Wiener Med. Woch., 1871, No. 44). Dr. Anstie records the severe case of a girl who had been treated in hospital with camphor, cod-liver oil, bromides, and zinc, also with succus conii in the dose of many ounces daily, yet without relief, and who recovered under 3 to 5-min. doses of Fowler's solution: he used at the same time ether spray to the spine, but this application has not proved itself of such power as he then thought it (Practitioner, June, 1874), and therefore I do not believe that it much influenced the result. Dr. Ringer considers arsenic as by far the best remedy in simple chorea; he remarks

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that failure may be owing to smallness of dose; also that children above five years of age bear nearly as much as adults, and that girls seem to require more than boys. Dr. Eustace Smith and others have also specially noted the tolerance of choreic children for arsenic, and the necessity of full doses to secure success (B. M. J., i., 1875). In my own practice, for upwards of twenty-five years, I have seldom known arsenic fail to cure simple chorea, although many of my cases were severe and of long duration, and quite incapacitated for the ordinary duties of life—3 to 10 min. of Fowler's solution thrice daily has been the dose usually prescribed by me, but I have frequently observed no permanent good effects follow until the development of some of the slighter physiological symptoms.

From the above quotations and remarks, though they represent an ample experience, we must not conclude that the value of this remedy is equally acknowledged by all. The counter-claims of iron, of zinc, of belladonna, etc., are urged by some observers, and the natural tendency to cure of the malady under favourable conditions is still more strongly insisted upon by others. Vogel, the distinguished Russian professor, classes arsenic with "a number of empirical remedies that are more praised than curative." Dr. Wilks attributes much more importance to rest (B. M. J., ii., 1876), and my colleague, Dr. Sturges, includes arsenic amongst a number of other "useless medicines" (Lectures on Chorea, 1876). In estimating the value of any remedy, we are constantly met by the difficulty of proving how far we have affected the course of nature; this difficulty is not greater with the present medicine than with others, and even allowing that chorea will recover with proper rest, food, and management, yet I am clearly of opinion that arsenic will promote, and quicken, and confirm the cure. I cannot affirm that it will always, of itself, and in despite of circumstances, control the disease. Judging from private practice and from hospital in-patient records, a large number of cases recover whilst taking arsenic, either far more quickly than is consistent with the ordinary course of the malady, or (making the contrast more striking) recover after many powerful remedies have been tried without effect under equal conditions. The ordinary duration of a chorea well managed,

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but without medicines, has been stated as six to eight weeks; if it continues three months Jaccoud considers it chronic, almost incurable, yet we have already quoted and have seen many cases that improved within two or three days, and recovered within three to five weeks, and we have quoted also cases of cure after a duration of many years. A certain proportion of cases of chorea are connected with embolism, and these were excluded by Dr. Anstie from the range of the beneficial action of this drug, but from what we know of its value in cerebral congestions, we should think it often appropriate even in such serious conditions. In markedly anæmic patients we might prefer iron, or at least combine it; and if sexual excitation were present, as in the case of some girls at puberty, we might substitute bromides or antispasmodics; acute rheumatic symptoms would also modify the treatment, but with these exceptions we must consider arsenic a most valuable agent in all varieties of the malady.

Tremor—Ataxia.—Allied to the use of arsenic in chorea, is its use (which, however, is much less markedly beneficial) in these nerve-conditions. Tremor may be due to various causes, which are often central and connected with organic disease, and scarcely amenable to treatment; but Eulenburg reports several cases successfully treated by hypodermic injection of 2 to 3 min. of Fowler's solution diluted with two parts of water (Berlin. Klin. Woch., 1872, No. 46). Isnard says the remedy is valuable in ataxia developed during acute fevers; he gives it even during febrile accessions.

Congestive Disorders.—The value of arsenic in the following group of cases seems best explained by its power, in small doses, to regulate and equalize the circulation in capillary blood-vessels.

Cerebral Congestion.—As a preventive of apoplexy, the remedy has a traditional, and perhaps not an easily proved, reputation, but one that would be quite in accord with our view of its action. Lemare-Piquot, after relating marked relief to giddiness, sense of oppression, epistaxis, and other premonitory symptoms, both in his own case and that of five other persons about sixty years of age, reasonably restricts its use to cases of cerebral congestion occurring in the strong and plethoric,

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who have an excess of blood-corpuscles (*v.* p. 426). He recommends from 4 milligrammes to 1 centigramme daily for about a month, taken at meal-times, and founds his latest conclusion upon forty-four cases occurring without one death (Bull. de Thérap., 1859, and Recherches sur l'Apoplexie, Paris, 1860). Cahen, writing upon its value in congestions generally, and cerebral hyperæmiæ in particular, traces it, as we do, to a regulating influence on vaso-motor nerves (Archives de Méd., Sept., 1863), and Dr. Handfield Jones expresses similar views. Hirtz has had reason to think it efficacious in obviating apoplexy, and suggests that it would tend to prevent atheromatous degeneration (Nouveau Dict.). It is extremely useful in cerebral congestion, and especially when there is puffiness below the eyes, drowsiness, and mental torpor, with sluggish, venous circulation, and suspicion of commencing atheroma. By a similar action, perhaps, it benefits the melancholy and those suffering from hypochondriasis, especially aged persons.

Epilepsy has been plausibly connected with congestion in and near the medulla oblongata, and certainly the older writers, such as Alexander and Duncan, have recorded cases cured under arsenical treatment. It is of necessity no more a universal cure than any other medicine is, but there seem to be some cases specially amenable to it—for instance, those that are connected, however remotely, with malaria. We must note a case recorded under the supervision of Dr. Bristowe, that of a lad of fourteen, described as anæmic, but free from evident organic disease, and who had suffered severely from epileptic attacks, mainly nocturnal, for about two years, and afterwards from attacks, day and night, so frequently that he remained unconscious for some days, and was apparently dying; being roused, however, from this condition, he remained partly paraplegic, and the fits, preceded by screaming and by an aura in the feet, recurred on movement of the legs, or on excitement; for nearly a month he took zinc sulphate in increasing doses with valerian, but remained in the same state, sometimes disturbing the ward for a whole night; he was then ordered 5-min. doses of Fowler's solution thrice daily, and although he was not made aware of any change in treatment, the attacks ceased at once for many days; they recurred for a time under excitement, and the

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numbness of lower limbs persisted for some days; eventually, however, he got quite well. There is evidently some alliance between such a case and cases of chorea, but the periods of insensibility indicate a more serious condition; the exact character of the "fits" is not, however, described (Med. Times, i., 1862).

Dr. Clemens (Frankfort) strongly recommends a "liquor arsenici bromidi," which he has used for twenty years in the treatment of epilepsy of all varieties with much success; it has relieved even in cases connected with thickening of skull and congenital malformation (Med. Record, 1877). This preparation is said to be more reliable than Fowler's, and to act well without increase of the daily dose: it is made by boiling potash carbonate and arsenious acid, of each 1 dr. in ½ pint of water: making up to 12 oz., adding 2 dr. of bromine, and mixing thoroughly.

Cardiac Weakness—Mitral Disease—Venous Congestion.—For such conditions, arsenic is often found serviceable, and under its use dyspnœa on exertion, the palpitation, the faintness, and the œdema of extremities have all improved. Dr. Papillaud has verified similar improvement, and also marked relief to palpitation, but he generally alternated or combined the remedy with antimony (Bull. de l'Acad. de Méd., Dec., 1870, p. 885).

When *intermittent pulse* occurs from cardiac weakness, whether of temporary character or dependent on degeneration or mitral disease, arsenic is often serviceable, as it is also in the same condition when due to nerve-causes. Darwin relates a case of "regular intermission" cured by 4-min. doses of a saturated solution of the drug (Headland, p. 197). I have seen numerous cases cured by the continued use of 2 to 5-min. doses of Fowler's solution after each principal meal. Under such circumstances it often produces a marked diuretic action, which is quickly followed, in many instances, by disappearance of any swelling, and by relief of the dyspnœa, faintness, and palpitation.

Albuminuria.—The influence of arsenic upon this condition is well worthy of further investigation. A case of "acute renal anasarca" in a woman, aged nineteen, is briefly recorded from Dr. F. Farre's practice (Lancet, i., 1862); six weeks after

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the commencement of the attack she developed psoriasis, for which Fowler's solution was prescribed, and under its influence the albumen disappeared, and the patient gained flesh and strength. I have for many years used it in albuminuria following scarlatina; it removes the dry inactive condition of the skin, checks thirst, and causes a copious flow of urine, which gradually becomes less loaded with albumen; should dyspnœa be present, the remedy quickly relieves it, and œdema of face and body disappears. In 1876 a case came under my care of chronic character, occurring in a builder, aged forty-three, of dissipated though hard-working habits; he had general anasarca and epileptiform convulsions, which were relieved for a time by laxatives, but the amount of albumen was uninfluenced by them, or by a long-continued use of iron. Fowler's solution was substituted, and the albumen diminished and soon ceased to appear; then, omitting the medicine, a relapse occurred; this again yielded on resuming the remedy, and the albumen, anasarca, and convulsions all disappeared, and in two to three months the patient's health was quite re-established, and he has since been quite well. I have also treated by liquor arsenicalis, with excellent results, numerous cases of *temporary or intermittent albuminous urine* dependent on imperfect digestion.

Dr. Brunton has discussed this subject in an interesting and scientific paper (Practitioner, June, 1877): he remarks on the important distinction between "true and false" albuminuria (Gubler), including under the latter term, not only the presence of albumen from pus or blood, but also the so-called Bence Jones' albumen, egg-albumen, the albumen absorbed from the intestine after imperfect digestion: it is a case of the latter kind that is recorded by him as being much benefited by arsenic, and it had several peculiarities. The patient was aged thirty-three, sallow and thin; the first symptom was great fatigue on exertion, then albuminuria was noticed (on examination for life insurance): it was at first present only during the summer; it came on after work and ceased on rest; it ceased also under strychnine (but this caused headache and sickness), and it ceased during quiet residence at the seaside. Fatty food brought it on, and meat taken in the morning, not when taken at night.

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Quinine and phosphoric acid at once increased the quantity, but rigid adherence to a farinaceous diet quite controlled it, and there were other evidences of its direct connection with digestion. After many years of treatment, including milk-diet, sea-voyages, digitalis, hydrarg. c. creta, etc., Dr. Brunton ordered 3 min. of Fowler's solution at meal-times, "and almost at once the albumen disappeared, and the patient was able to do much more work than usual, without its return." Later, the medicine was changed for hypophosphite of soda, and the albumen returned, to cease again on resuming arsenic. The whole case is very interesting, but we need only mention further that pancreatine, which increases pancreatic digestion and aids in the solution of albumen, was also found beneficial. This affection should be classed under faulty digestion or assimilation rather than as renal disorder. The special form of chronic albuminuria in which I have proved its value is that dependent upon venous congestion, mitral disease, or emphysema, after the right ventricle has begun to yield, but it deserves a trial also in cases where the actual kidney structure and epithelial lining are affected. I have carefully watched many of these latter cases in which the beneficial action of arsenic was very marked.

Uterine Congestion.—This condition may accompany either menorrhagia or amenorrhœa, and that arsenic may remedy either symptom is, therefore, not contradictory. In the former, the catamenia being too copious and too frequent (leucorrhœa often occurring in the intervals), and the patient becoming weak and anæmic, small doses of from 2 to 6 min. thrice daily will be found to lessen the flow and to improve appetite and general health. Mr. Hunt has recorded some striking cases of uterine hæmorrhage at various intervals after labour or miscarriage, some accompanied with symptoms only of irritable uterus, "but for the most part atonic in character" (Med.-Chir. Trans., vol. xxi.); all improved under arsenic. Sir C. Locock found great advantage from it in similar cases. Dr. A. Burns, from experience of it in all varieties of uterine hæmorrhage, has reason to express the greatest confidence in the remedy, and records several cases treated by rather large doses, 10 to 20 min., repeated every

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fifteen to twenty minutes (Amer. Journ. Med. Sci., Oct., 1859).

Amenorrhœa.—When this depends upon congestion or torpor of the uterus, or is connected with anæmia or chlorosis, I have known arsenic succeed well, and have several times found that when iron preparations had been taken without marked result, the addition of arsenic was quickly followed by relief—it seemed to act as a regulator of the circulation and as an uterine tonic.

Hæmorrhoids.—The efficacy of arsenic in this form of venous congestion has been sometimes well shown; thus, in one case, a gentleman had suffered for many years, and had undergone cauterizing and other operations, when this remedy was given to him for hay-asthma, and he found his hæmorrhoids to be more relieved in a few days than under any other treatment. Relapses occurred more than once, but always yielded in a few days to 8-min. doses of Fowler's solution (Parvin, in Braithwaite's Retros., ii., 1866). I can recommend it strongly in painful hæmorrhoids, and also for ordinary external piles.

Cutaneous Disease.—Arsenic is largely used by the profession, almost as a routine remedy, in cutaneous disease, but its value has been variously estimated by specialists of experience. We may exclude at once from its influence the ordinary acute exanthemata, also nævus, parasitic and syphilitic eruptions, and the rarer maladies of scleroderma, keloid, xanthelasma, and true leprosy. We may exclude also all forms of skin-disease whilst in the *acute* stage, or whilst accompanied by marked inflammatory reaction, and then, speaking generally, we may say that as we have noted arsenic to be valuable in rheumatic, malarial, and neurotic affections, so is it also valuable in most cutaneous manifestations of these conditions. With regard to the last-mentioned, my own experience agrees rather with that of Hunt and of Anstie, as against Bazin and others, that in neurotic subjects with highly-strung excitable natures, arsenic is less readily borne, and more usually causes diarrhœa.

The forms of skin-disease in which the remedy is of generally accepted value, are such as psoriasis, eczema in the dry or scaling stage, pemphigus, lichen, alopecia, and chronic urticaria; and

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those in which its powers are more controverted are acne, lupus, ichthyosis, herpes zoster,[1] sycosis, prurigo, epithelioma, cancer, and elephantiasis græcorum.

Psoriasis.—From the time of Girdlestone (1806), Willan and Bateman, Biett and Cazenave, arsenic has held the first place in the treatment of this malady. Modern dermatologists agree upon this point, but some, as the late Mr. Startin and Mr. Hunt, rely upon this drug much more positively than others. The preference of Hebra for local over any constitutional treatment is well known, but even he recognizes "a decided curative action of arsenic in this form of disease." Dr. Tilbury Fox inclines to restrict its use to the more typical cases, especially those of chronic character and accompanied with nerve-debility; on the other hand, many cases will be found to occur in persons otherwise strong, and in such cases after preliminary purgative treatment I have found the remedy useful. "Before undertaking to deal with psoriasis," remarks Gaskoin, "it is necessary to know all about arsenic" (Treatise on Psoriasis). Its success, however, is, as Stillé remarks, by no means uniform, and any want of due attention to the excretions, to the presence of gouty or other constitutional tendencies, or to the proper regulation of dose, will readily prevent a satisfactory result. It can by no means be considered a specific, but as a valuable agent only under certain conditions; neither can it be accurately stated that "the more chronic the malady the more suited it is for this remedy," for after it has lasted for eight or ten years I have seldom found it amenable, and Devergie has recorded a similar experience (Maladies de la Peau).

Mr. Malcolm Morris notes that sometimes arsenic not only does no good in psoriasis, but harm, in rendering the patches more hyperæmic and irritable; he finds it impossible, however, to diagnose the cases in which this may occur (Practitioner, 1880).

In judging of its true power, we must allow for the natural improvement of the malady in certain circumstances, *e.g.*, on the cessation of lactation, at changes of climate or of season,

[1] The reason for doubting the value of arsenic in herpes is that it is a disorder of definite course, which must develop, but the neuralgic pain, if severe, is markedly lessened by arsenic (*v.* p. 469).

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etc., also for the effect of external treatment by tar or bathing carried on at the same time. But after these allowances there remain, no doubt, many cases which show improvement distinctly from arsenic; the best illustrations are seen in children, and then in older persons in whom the attack is comparatively recent yet not in an acute stage; chronic cases that have been left untreated often do well, but previous irregular trials diminish the chances of recovery. In any case, if cure be effected, freedom from relapse cannot be guaranteed (Wilson); Hunt has shown how important it is to secure a due action of the absorbents, and also that one preparation may succeed when another has failed; for instance, to one of two girls similarly affected, he gave the potash, and to the other the soda solution; for a time both did well, and then both ceased to improve, but later on, when he exchanged their medicines, they progressed to cure (Journ. Cutan. Med.).

Eczema.—In this, which is a catarrhal form of disease, arsenic has not so large a measure of success as in the last-mentioned; still it is often very useful, and especially in combination with other remedies. Acute cases not only receive no benefit, but I have seen them much aggravated by it; the proper period for its use requires, therefore, careful consideration. It is very suitable in scaly,—which are of necessity rather chronic stages, and have received the distinct name of "eczema squamosum,"—in superficial subacute forms with moderate infiltration, and in cases with persistent irregular patches about the scrotum, anus, or vulva (Rayer), or about the hands or fingers (Duhring). Sometimes the later stages of a chronic infantile eczema seem much benefited by the addition of the drug to iron or cod-liver oil, and sometimes an infant has been successfully treated by arsenical medication through the mother (Begbie, Anderson). The last-named observer, in his excellent special treatise, estimates the value of arsenic highly: he points out, as others have done, that children will readily bear a proportionately large dose; at the same time, he notes that there is much tendency to "catching cold," or even bronchitis, during an arsenical course, also he insists on the necessity for its prolonged continuance. Mr. Erasmus Wilson considers that the treatment of eczema resolves itself into that of "debility,"

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and advocates the use of arsenic "as a nerve-tonic and stimulant to cutaneous function;" and generally combines it with a non-astringent preparation of iron, as the vinum. My own use of arsenic in ordinary eczema is rather the exception than the rule, and I am much in accord with Dr. Piffard, who, after calling this mode of treatment "empirical, as opposed to rational," and quoting the prevalent opinion, "that if only sufficient of the remedy be used, the eruption must yield," states that, in his experience, it sometimes does harm and at other times has no influence, though in a minority of cases will give brilliant results: these may be hoped for in the dry scaly stages when extensive tracts of surface are affected (On Skin Diseases, 1870); I would add, and when there are persistent patches on the pudenda or extremities, as already described.

Pemphigus.—There is an ephemeral form of this malady in which one or two crops of bullæ come out, and subside under mild general treatment; there is also a syphilitic form, mainly congenital, and an epidemic form which occurs sometimes in lying-in and in children's hospitals, and is connected probably with blood-poisoning; in none of these do we expect benefit from arsenic. There is a fourth form, occurring sometimes in the later months of pregnancy, which may be severe, and although it tends to subside after parturition, yet may receive some benefit from the remedy; but the variety of the malady to which we would specially refer is that known as "pemphigus diutinus, in which the blebs come out freely, often symmetrically, and extensively,—which often lasts long, and almost invariably exhibits its constitutional origin in a marked tendency to recur." Mr. Hutchinson, from whom I quote, has certainly furnished us with valuable evidence of the great power of arsenic in this variety, and although by Hebra and others it is commonly held to be incurable, and often fatal, Mr. Hutchinson "has never met but with one case that resisted this treatment, and has come to consider the malady as one of the most hopeful." (Med. Times, ii., 1875). He furnishes an abstract of twenty-six cases that have been under his own observation, and refers to others in the practice of Hillier, Wilks, Fagge, Startin, etc.: many of them had relapses, but these were mild in character. In many, the influence of the medicine was proved by the rapid improve-

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ment, and by relapse, on resumption and omission of it respectively, and in at least one case it appeared to prevent a patient's death. A delicate man, aged forty-four, recently become subject to epileptic attacks, presented a general rash, at first very like herpes, and attacking the face and extremities. There was much prostration, and the patient was treated with quinine and iron, and liberal diet, yet became extremely emaciated, and as the pemphigus character became more developed, he was covered with large superficial sores and completely prostrated; then the tonics were stopped, and 4 min. of Fowler's solution prescribed, and from that day no fresh blebs appeared until a few weeks later when nearly well and able to leave his bed: it was then found that his medicine had been omitted for three days, and on resuming it, the blebs at once receded, and six weeks afterwards he was in good health and wholly free from eruption (Op. cit., p. 625). Dr. James Russell has also published a well-marked case in a child in whom the numerous relapses were always distinctly controlled by arsenic (Med. Times). On the other hand must be noted the observations of the late Dr. Tilbury Fox: "There is no specific for pemphigus; arsenic is declared to be one, but it often signally fails to cure the disease, and I have seen quinine, in full doses, do much more good."

In **Lichen Simplex**, and certainly in its more chronic forms, the value of arsenic is generally conceded. Dr. Liveing's expression is, "In chronic lichen it is the only remedy;" but, as a rule, alkalies are required in addition, and mercurial treatment may succeed still better. A similar observation would apply to another form of papular disease—true prurigo.

In **Lichen Planus**, Mr. Morris (loc. cit.) and others speak well of it. Thus, a lady, aged fifty, with an itching eruption of flat-topped violet-coloured papules, slightly scaly, situated on the inner side of the thighs and outer sides of forearms, took 8 min. of liquor sodæ arseniatis, at first twice and then three times daily, and the eruption faded in one month, and the treatment being continued for a time, no relapse occurred (how long the eruption had lasted is not stated). He considers arsenic "an invaluable remedy." Dr. Fox has, however, seen no benefit from it.

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In the more generalized form of the malady, Hebra, who names it "lichen ruber," places much reliance on the "Tanjore pills" (arsenic with black pepper).

Alopecia.—From the effect of arsenic in improving the coat of horses, it has been plausibly thought to have a special power in promoting hair-growth, and certainly after any sources of baldness, such as syphilis, dyspepsia, or local irritation, have been treated and removed, the internal administration of small doses may be carefully carried out for a time with advantage. Hunt practised this treatment successfully.

Chronic Urticaria is often relieved under arsenic, but any evident intestinal disorder should, if possible, be remedied in the first instance.

Acne.—In acne it should be the exception to prescribe arsenic. Mr. E. Wilson goes so far as to say that "no one having even a rudimentary acquaintance with cutaneous pathology and therapeutics would think of doing so," and yet I have certainly seen cases cured by this remedy after others had failed. According to Dr. Bulkley, this has occurred with all forms of acne—the simple, the indurated, and the rosaceous—and his best results have been attained with De Valangin's solution of chloride. Dr. Duhring speaks well of it in the indolent papular form, and many special authorities might be quoted to the same effect. This does not seem to me so unreasonable as it does to Mr. Wilson, for acne is frequently connected with gastric and uterine irritation, and we have seen that arsenic has great power to relieve various forms of this malady.

In "bromic acne"—the pustular rash which frequently follows the use of full doses of any bromide—arsenic is decidedly useful. If given concurrently with the bromide it will often prevent any skin-trouble (Bartholow; also Gowers, Lancet, i., 1878), and I can corroborate this observation.

Lupus.—There are differences of opinion as to its value in lupus: Mr. Hunt, for instance, and Mr. Milton esteeming it highly, and recommending its continuous administration for months or years; but others, and, indeed, the majority of observers, recording no definite result from it. I have never been able to satisfy myself that it controlled the disease,

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although the local caustic effect is, as already mentioned, highly valuable.

Ichthyosis is congenital, and, though it may be relieved, is scarcely curable; the evidence as to the value of arsenic in its treatment is but slight.

Herpes Zoster.—Trousseau has observed that the pain in the course of affected nerves, which is often severe and long persistent in the zoster of elderly persons, may be relieved by arsenical medication, though this will not cut short the course of the attack itself (Clinical Medicine).

In **Sycosis**, non-parasitic in character, there is much evidence of the value of the drug, and this would accord with what we know of it in other cases of pus-formation. Dr. Laycock has used an arsenicated glycerine (2 dr. of Fowler's solution in 10 dr.) as a local application, with good results; it is somewhat strong, and acts as a "substitutive irritant" (Med. Times, ii., 1864).

Erysipelatous Inflammation of a phlegmonous type is liable to give rise to sloughing, but if, at the first appearance of this change, small doses of arsenic be administered, together with a generous diet, the more severe results may be warded off, and even after sloughing has taken place, arsenic will often control it effectually.

In **Hospital Gangrene** the results obtained strongly incline me to consider it very beneficial. In twelve cases in which I have tried it, giving 4 to 10 min. of Fowler's solution every two or four hours, I was well satisfied with the result, especially as arsenic was the only active treatment used; no local caustics were needed. In various other affections of gangrenous character the same remedy has proved very reliable.

The so-called "cancrum oris" and ulcerations about the tongue often receive benefit from the same treatment.

Epithelioma, etc.—Cases of this disease affecting the lip, the tongue, the scrotum (chimney-sweep's cancer), etc., are stated to have been cured by its internal administration; and although Hirtz concludes that all reports of true cancer being cured by arsenic internally are founded on mala fides, or bad diagnosis, yet there is some trustworthy evidence of its relieving cancerous pain in the stomach and in the uterus. Sir C. Locock

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mentions his own confidence in it, together with cases from his practice, and from that of Brodie and of Sir A. Cooper (Lancet, 1837), and Mr. Hunt records a marked instance of relief under small doses frequently repeated, not amounting to more than 10 min. in twenty-four hours. The case was said to be undoubted uterine cancer, and the relief given was greater than from morphia: as a rule, a pill was preferred, containing $\frac{1}{10}$ gr. or less. Fordyce Barker also speaks highly of its power to relieve pain and improve the general condition, in doses of about 3 min. of Fowler's solution (Amer. Journ. Obstet., Nov., 1870). Dr. Walshe has written specially to recommend the iodide of arsenic as most valuable (Dub. Quart. Journ., Aug., v., 1857, p. 9). I have given Fowler's solution internally in many cases of epithelioma, when the disease was extending rapidly, and have known it apparently retard for a considerable time the progress of the malady, relieve the pain, and improve the general condition. Cases where the lower lip or the scrotum was affected have given me the best results: the dose usually prescribed was 5 min. thrice daily.

Elephantiasis Græcorum (Leprosy).—Dr. Waring says that for this almost incurable disease arsenic is still highly esteemed in India, and Dr. Benet (formerly of Lahore) records benefit from the Tanjore pill (Gaz. des Hôp., Dec., 1842). The external application of arsenious acid is also reported to have cured (Dub. Med. Press, 1864), but this must be exceptional.

Disorders of Mucous Membranes.—Without implying that the following maladies are *solely* disorders of mucous membranes, it will be found convenient to group them under this heading. The value of arsenic in them is very marked, but is of comparatively recent recognition, and has not yet been noticed in many text-books.

Coryza—Bronchial Catarrh—Hay-Asthma.—In these disorders, in which a profuse secretion is connected with local irritation, and with generally depressed nerve-power, Fowler's solution is often effectual, and it is especially so in patients subject to paroxysmal sneezing, with much itching about the alæ nasi. Dr. Mackenzie had previously reported satisfactory cases of catarrh treated by doses of 3 min. and upwards (Lond. Med. Journ., July, 1851).

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Chronic Bronchitis.—I have witnessed marked improvement under the continued internal arsenical treatment of chronic bronchitis, for which cigarettes and inhalations are sometimes even more suitable than ordinary doses. Bretonneau and Trousseau have recorded good results, and the latter devised a simple cigarette, made with suitable paper, soaked in solution of arseniate of soda, or of potash (1 to 4 gr. in 20 gr. of water for twenty cigarettes). Four or five mouthfuls are inhaled several times daily; more often when the patient becomes accustomed to it. M. Papillaud recommends, in chronic bronchitis and emphysema, a combination of the drug with antimony (an arseniate of antimony), and considering the relations between these two substances, the recommendation is likely to prove very good (Gaz. de Paris, 1865, No. 43, etc.)

Dyspepsia.—In many cases even of irritative dyspepsia, when the tongue is furred, with red edges and tips, and there is pain after food and heartburn, and tendency to diarrhœa after eating, I have had ample experience of the value of Fowler's solution given in 2 or 3-min. doses after meals. Dr. Thorowgood finds that it acts best when the attack seems localized in the stomach, and is independent, *e.g.*, of hepatic congestion (Practitioner, 1870). Dr. Anstie, whose first published observations were directed to the value of arsenic in gastralgia, previously mentioned to me its equal efficacy in the dyspeptic conditions described.

Vomiting—Diarrhœa.—In chronic forms of vomiting connected with ordinary dyspepsia, and in that of alcoholism which occurs usually in the early morning, and is of a bilious character, with painful straining, arsenic is often useful: also in the retching and vomiting of pregnancy I have obtained excellent results from 2 to 5-min. doses. Dr. Décamp has highly recommended the same treatment (Philadelph. Med. Surg. Reporter, 1872, No. 27), and Bartholow mentions, as additional indications for it, the rejection of the food, *streaked with blood*, or blood only, also gastralgia and interscapular pain. It is not only serviceable in cases of the rapid passage of half-digested food occurring very soon after meals, but also in cases where the motions are frequent, watery, containing mucus, offensive and irritating to the anus, and even when bloody

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and dysenteric in character and accompanied with tenesmus, prostration, and vomiting. In true dysentery, especially when of malarial origin, and verging into a chronic state, arsenic is often of the greatest value.

Chronic Gastric Catarrh.—In cases of this malady marked by oppression and discomfort after eating, with a sense of weakness and emptiness at the stomach, thirst, offensive breath, coated and red-edged tongue, flatulence and pyrosis, with rejection of glairy acid fluid, and general symptoms of depression, coldness of extremities, and emaciation, I have had ample experience of the good effect of small doses. In acute gastric catarrh also, I have not been often disappointed, though a more cautious use is needed, but in the chronic forms, especially when co-existing with emphysema, with chronic bronchitis, or with phthisis, arsenic always gives some relief. Germain speaks favourably of the treatment (Gazette Hebdomadaire, 1860), and Trousseau remarks that the evidence in its favour is such as to warrant a fair trial of it. Many mineral waters that have a reputation in chronic gastric maladies contain an appreciable quantity of arsenic, notably those of Mont Dore, Plombières, and Bussang. Dr. Wilson Fox, however, whilst referring to the favourable reports of others, states that "he has not had successful results himself, possibly because he has not seen definite indication for the remedy"; sometimes it seemed to aggravate the malady (Reynolds' System, ii., p. 884).

Gastro-enteritis—"English Cholera."—Fowler's solution is an effective medicine in severe cases of this disorder. I have seen it give relief when the patient was suffering from retching and bilious or sanguineous vomiting, passing white, odourless, or slimy flocculent stools, with pain, tympanitis, and tenesmus; other symptoms present have been—thickly-coated tongue, thirst, pyrexia and prostration, muscular cramps, scanty urine, pinched and anxious features. Even when the stage of collapse has commenced, and the surface is dusky and covered with cold perspiration, the medicine has seemed to me of great service—5 min. every one or two hours was the dose given, lessening it as the patient improved. Black has written very fully in praise of this remedy in English cholera, recommending 10 to 15 drops every ten to fifteen minutes till the symptoms abate, then

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less frequently. He has found this most valuable in various forms of choleraic attack, but especially in serious cases connected with defective drainage, and presenting the symptoms of vomiting, purging, and rapid collapse; he records several instances of immediate and striking improvement (Lancet, ii., 1857). Dr. Hitchman speaks equally strongly, and describes fully the indications for arsenical treatment in such cases (loc. cit., p. 535).

Cholera Infantum.—This term has been applied to dysenteric diarrhœa in children, probably because of the collapse so readily induced. The child looks pale and thin, and refuses food, the motions are very frequent and brown, offensive, and mixed with blood; tenesmus also is commonly present, and often with such symptoms minim doses of Fowler's solution produce excellent results.

Gastric Ulcer.—Not only in chronic inflammation, but in ulceration of the mucous membrane of the stomach, I have seen very beneficial results from arsenic, the appetite returning, and the thirst, the vomiting, and the pain subsiding, so that the patients became strong and stout who had before been weak and emaciated. Dr. Ringer has observed similar results, and states that he has seen relief from this remedy in chronic ulcer after failure of the more commonly-used medicines (Op. cit., p. 253). I usually prescribe 1 to 5-min. doses four times daily with a little nourishment.

PREPARATIONS AND DOSE.—*Acidum arseniosum:* dose, $\frac{1}{60}$ to $\frac{1}{16}$ gr. in solution or pill. *Liquor arsenicalis*—Fowler's solution (4 gr. in 1 fl. oz.): dose, 2 to 8 min. *Liquor arsenici hydrochloricus* (4 gr. in 1 fl. oz.): dose, 2 to 8 min. *Sodæ arsenias:* dose, $\frac{1}{16}$ to $\frac{1}{8}$ gr. *Liquor sodæ arseniatis* (4 gr. in 1 fl. oz.): dose, 5 to 10 min. *Liquor arsenici et hydrargyri hydriodatis* (not officinal): dose, 10 min. to $\frac{1}{2}$ fl. dr., diluted, and given with the usual precautions for preparations of arsenic. *Ferri arsenias:* dose, $\frac{1}{16}$ to $\frac{1}{2}$ gr.

Liquor arsenicalis, if long kept, is liable to vary in strength on account of the deposition of a thin film of metallic arsenic; the compound tincture of lavender contained in it is nauseous to some palates, and would be better omitted.

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The solution of chloride is liable to become cloudy in warm weather, from the development of a fungus: this may be prevented by the addition of a little perchloride of iron (Hunt).

In acute or subacute maladies, as of the stomach or intestine, small doses, 1 or 2 min., either every hour, or every four or six hours, are suitable; in chorea, or neuralgia, or struma, where there is no visceral irritation, the dose may be gradually raised to 10 or even 15 min., and in chronic conditions of ague, or of cutaneous disease, the secret of success will be found in securing the tolerance of a moderate dose for a considerable time.

In agues, it is true that a large dose may be required, and may be well borne during a certain condition of the system, but so soon as that condition is relieved the large dose cannot be tolerated.

In skin-diseases, large doses are never desirable, and any increase beyond 4 or 5 min. should take place only after this dose has been used three or four weeks without physiological symptoms. This remark refers especially to the potash and to the acid solutions, not to that of the arseniate of soda, for although nominally of the same strength, the last-mentioned is markedly milder, and is often better borne in doses of 6 to 8 min., or more, than the others in less quantities. The remedy, sufficiently diluted, should always be given in several such moderate quantities daily, rather than in one full dose, and always at a meal, or with some food, so as to secure absorption and lessen the degree of local irritation; the symptoms of its physiological action, such as irritation of conjunctivæ, œdema, nausea, etc., should be constantly watched for, and the dose diminished rather than entirely omitted, if the reason for its administration remain.

In some obstinate cases, especially of chorea and of skin-disease, it is justifiable and not harmful to keep up a moderate degree of physiological action for some time, but this must be done very cautiously. It is a matter of daily experience that the secretions must be in good order if we are to expect the full advantage of the remedy in chronic disease. Mr. Hunt observes, "Above all, the bowels must not be allowed to act sluggishly.

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In many cases a full dose of calomel and compound colocynth pill will be required two or three times a week, and these doses are sometimes essential to the cure. If the legs, or feet, or abdomen become œdematous, and the urine scanty, the case will not go on well till we have roused the kidneys to vigorous action by full doses of spiritus ætheris nitrosi and acetate of potash, etc." (Journ. Cutan. Med., ii., p. 353).

The administration and the powers of arsenic in combination with other remedies require special consideration. We have already noted that it enhances the value of iron, for instance, in amenorrhœa, anæmia, struma, eczema, etc., and Messrs. Young and Postans have introduced a good effervescing citrate of arsenic and iron, which I have often found serviceable. The direct combination of iodine and arsenic has been esteemed by some practitioners on the Continent and in Ireland, especially by Neligan: from $\frac{1}{10}$ to $\frac{1}{4}$ gr. in pill thrice daily has been given. The same physician employed also an iodurette solution, containing 5 min. of Fowler's solution, 1 gr. of iodide of potassium, and $\frac{1}{4}$ gr. iodine in 1 dr. of orange syrup; it is rather agreeable, and keeps well, and has given good results. He found this preferable to Donovan's solution (Dub. Journ., vols. xvi., xviii., xxii.), (*v.* p. 418). This has been specially used in syphilitic skin-disease, but it is, as Mr. Hunt observes, though "very active, yet a most unmanageable preparation." The mercury is liable to injure the general health of some weakly subjects, and to interfere with the effects of arsenic or of iodine, which are quite powerful enough, and require special caution as to their own effects. Dr. Clemens, of Frankfort, recommends a direct combination of arsenious acid and bromine, and Ferris and Co. prepare a liquor arsenici bromati.

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AURUM—GOLD, Au, = 196·6 (not officinal).

This "king of metals," as it was formerly termed, is found native in the "veins" of rocks, and as gold-dust or nuggets in the sands of certain plains and rivers; it is separated by washing, or by means of mercury, which is afterwards driven off by heat; it occurs also in alloy with silver, copper, and iron, but not as an oxide, nor in any other than the metallic form.

CHARACTERS AND TESTS.—When pure it is of yellow colour, having a tinge of green by reflected light, and is decidedly greenish when liquefied; it is of great density (sp. gr. 19·5), and is remarkably malleable, 280,000 thin leaves making only one inch in thickness. It is less easily oxidized than any other metal, and will not combine with oxygen by direct action, only through the medium of another oxide: thus the protoxide of gold is prepared by adding solution of potash to one of protochloride; it precipitates as a green powder. Gold combines also with chlorine and iodine, not with nitrogen or hydrogen. It is soluble only in a mixture of nitric with hydrochloric acid (aqua regia).

PULVIS AURI—POWDER OF GOLD (*not officinal*).

PREPARATION.—By triturating gold leaf with some hard crystals, as of potassic sulphate, or with some glutinous substance as honey; and after complete disintegration of the metal, the foreign ingredient is removed by washing—the resulting powder retains the colour of the metal.

COMPOUNDS OF GOLD.

AURI PERCHLORIDUM—PERCHLORIDE OF GOLD—"POTABLE GOLD" OF ALCHEMISTS, $AuCl_3$, = 303 (*not officinal*).

PREPARATION, etc.—By dissolving the metal in nitro-hydrochloric acid, with gentle heat. On evaporating, yellow crystals of the salt are left in combination with some free acid

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($AuCl_3 2HClH_2O$). After the acid has been driven off, the colour of the crystals is red, and they have the composition, $AuCl_3$. This salt is used in photography and in analytical chemistry, and a solution of it, freed from excess of acid is, placed in the appendix to the Pharmacopœia as a test solution for atropia.

AURI PEROXIDUM—PEROXIDE OF GOLD—"AURIC ACID," Au_2O_3, = 441·2 (*not officinal*).

PREPARATION, etc.—By treating the perchloride with magnesia, washing the precipitate, and digesting in dilute nitric acid, which removes the magnesia. The peroxide forms, when dried, a brown powder, insoluble in water, and decomposed by exposure to light.

AURI ET SODII CHLORIDUM—CHLORIDE OF GOLD AND SODIUM, $AuCl_3NaCl2H_2O$ (*not officinal*).

PREPARATION, etc.—By mixing in solution about 5 parts of chloride of gold and 1 part of chloride of sodium, and evaporating to crystallization; long, four-sided prisms are left, of deep yellow colour. This combination, which is deliquescent and soluble in water, is the form most commonly prescribed; it has a nauseous taste, and should not therefore be given in solution.

AURI IODIDUM—IODIDE OF GOLD, AuI_3 (*not officinal*).

PREPARATION, etc.—By mixing solutions of iodide of potassium and perchloride of gold. The precipitate, when collected, washed, and dried, forms a greenish yellow powder, insoluble in cold, but slightly soluble in boiling water.

ABSORPTION AND ELIMINATION.—Salts of gold are readily decomposed by organic substances, and they coagulate albumen, but when the soluble chlorides are given internally they become absorbed to some extent, probably in the intestine, as oxides combined with albumen. When rubbed upon the gums and tongue, according to an old-fashioned method of administration, they are also absorbed, but are

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liable to cause much local irritation. Neither metallic gold nor the oxides can be absorbed (although poisoning by gold leaf is said to be an aristocratic method of suicide in China), nor is an ointment containing either these or the chlorides likely to produce any effect through the skin.

Elimination occurs through the liver, the intestinal canal, and the kidneys, but is very slow (Husemann): the urine is coloured yellow during the process. Rabuteau maintains that the elimination of gold is never complete, some of the metal being reduced and deposited, especially in the epithelial and nerve-tissues; for on examining these parts in the body of a rat that had died after taking 15 gr. of gold chloride in fourteen days, he found the contour of epithelium from the intestinal tract to be very strongly marked, as by nitrate of silver, and the axis-cylinder of the nerve-tubules to be coloured slightly green; he considers that this deposition of the metal explains why gold seems more active than mercury, for having nearly the same atomic weight and specific heat, their properties should (according to the analogies of other substances as observed by him) be also very similar, were it not that the gold is less completely eliminated (Op. cit.). We must remark, however, upon this point, that though mercury may, as a rule, be more readily eliminated than gold, yet it has also often been found deposited in bone, liver, and other parts of the body, long after its administration.

PHYSIOLOGICAL ACTION.—*External.*—The chloride of gold has an irritant and caustic effect, and stains the skin of a yellow colour, which becomes violet, and later black, from reduction of the metal.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Small doses increase appetite and digestive power, and stimulate the secreting organs; but under larger or continued doses, this stimulation readily passes into irritation, and there are often dryness of the tongue, redness of the pharynx, and some gastric irritation, with colic and diarrhœa (Cullerier); on the other hand, though the intestinal secretions are increased, constipation has been noticed by several observers.

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Glandular System.—*Salivation* has been commonly described as a result of this medicine, and is said to occur after a longer period, and with less marked stomatitis than when produced by mercury. Martini met with it (ptyalism) only after the long-continued use of small doses, and found that the double chloride of gold and sodium might be taken for many months without injurious effect; only in one case did ptyalism occur, and then one-third of an ounce had been taken (Schmidt's Jahrb., June 23rd, 1870). The secretion of the sweat-glands is increased, especially during the night, and this alternates with or accompanies an increase in the quantity of urine (Gozzi, Bologna, 1817). The stimulation of the glandular system and of growth is said to be such that adenitis has followed the use of gold, and tumours of osseous or of glandular character have become painful and inflamed (Percy, Rapport à l'Academie). Some excitement of the genital organs occurs, so that in men priapism may be caused, and in women the catamenia increased (Legrand, De l'Or).

Nervous System.—The intellectual powers are said to be stimulated by gold somewhat in the same manner as by alcohol.

Toxic Effects.—A peculiar febrile condition—"auric fever"—including headache and many of the above-mentioned symptoms, as sweating and diuresis, may supervene if a course of the remedy be continued for two to four weeks, and seems to be analogous to mercurial fever (Niel, Recherches, Paris, 1820, etc.). In animals, general emaciation and convulsive twitchings have preceded death, and besides the evidence of metallic deposition in the tissues, Rabuteau records a yellow coloration of the gastro-intestinal mucous membrane. Large doses of gold compounds may certainly cause gastritis and death, with cramp and other severe nerve-symptoms (Majendie).

SYNERGISTS.—Mercurials.

ANTAGONISTS — INCOMPATIBLES. — Albumen in any form,—milk, flour, etc.

THERAPEUTICAL ACTION.—*External.*—As a caustic, the chloride has been used by Landolfi and Recamier in lupus and in carcinoma. Legrand employed it as a caustic in ulceration of the neck of the uterus, and also as a lotion

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and a vaginal injection (Op. cit.). Mechanically, the gold leaf is employed by dentists for stopping teeth, and by druggists for coating pills.

THERAPEUTICAL ACTION.—*Internal.*—In former times, when fanciful analogies of colour or of accidental qualities largely determined opinion as to the medicinal value of any substance, gold was praised as a remedy for melancholy, and for the dyspepsia often connected with it, and after several centuries of disuse its therapeutical power has been, to some extent, revived mainly by a few French and Italian physicians. The double chloride of gold and sodium is the preparation most recommended; it bears somewhat the same relation to the pure metal as corrosive sublimate does to mercury.

Syphilis.—M. Chrestien, of Montpellier, and later, M. Legrand, have reported many cases of both primary and secondary syphilis cured under the influence of gold, and Trousseau observes that such results are now well proven and incontestable. Chancres and condylomata have got well under this remedy in a manner not likely to be due to nature, and in my own experience its efficacy has been still better seen in the later developments, such as ulceration in the nose and larynx, cutaneous syphilides, hard nodes, etc. It is said to cure without local applications, but often an "unguentum auri" has been used in addition. Gold may especially be employed in long-standing cases with chronic periostitis, and when mercury has been already given to saturation.

Dietrich, whilst denying to gold any true anti-syphilitic power, thought it most valuable for mercurial cachexia (Journal des Connaisances Med.-Chir., 1840), but this has not been corroborated by many observers. Auric fever may occur during a course of the remedy, and for a time the general health may suffer, and the local manifestations may be more irritable, but on lessening the dose, pyrexia subsides, and good effects are more conspicuous.

Scrofula.—Advocates of the medicinal use of gold—especially Niel and Legrand—have spoken strongly of its value in scrofulous disease of the bones, in glandular enlargements, "white swelling," goître, and even elephantiasis; but Velpeau

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and others have not corroborated their good results in hospital practice. No doubt, as Trousseau remarks, the treatment of scrofula amongst the poor really requires more than any drug can effect, and it would be unfair to discredit gold altogether because it has not cured some hospital patients. I think myself that it may prove a useful adjunct, or at least a good alternative treatment. Majendie and Roux have reported some illustrations of its value, and Mr. Chatterley has recorded a case of extensive and indolent scrofulous ulcer affecting the right foot, unrelieved by iodide of iron, etc., but cured by small doses of the gold chloride (Lancet, ii., 1852, p. 455); also another case of cure of a cachectic child suffering from enlarged and indurated cervical glands (Med. Times, i., 1854, p. 447); he recommended $\frac{1}{24}$ gr. mixed with orris-root to be rubbed on the tongue for one to five minutes daily.

A case of hypertrophy of tongue with induration, which was probably syphilitic or scrofulous in character, was cured by the use of 1·5 gr. internally, and local frictions with 1 gr. mixed with lard (Amer. Med. Journ., vol. xix., p. 514).

It is probable that the so-called cures of cancer by aurum have really been of scrofulous ulceration.

Uterine Disorders.—Nöggerath refers to the value of this medicine in amenorrhœa, and in chronic ovaritis, and says it is suitable for cases of the former dependent upon torpor; it should not be given during pregnancy, nor to persons liable to undue flooding. Martini states that it is serviceable in cases with a tendency to abortion, in chronic metritis, and in sterility "dependent upon atrophy of the vaginal portion of the uterus," also in ovarian dropsy. He observed benefit from it as regards mental symptoms of hysterical character, and especially when these were connected with definite uterine disorder or disease (Schmidt's Jahrb., loc. cit.).

Chronic Bright's Disease.—Dr. Bartholow draws special attention to the value of salts of gold in the treatment of granular and fibroid disease of the kidney and "depurative disease." He has observed remarkable improvement from the persistent use of small doses of the chlorides—$\frac{1}{30}$ to $\frac{1}{20}$ gr., three times daily (Materia Medica, p. 188). They are not suitable for acute stages.

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Dyspepsia, etc.—Dr. Bartholow is also one of the most decided of modern writers in recommending small doses ($\frac{1}{20}$ gr.) of the double chloride for "nervous dyspepsia," as "indicated by a red glazed tongue, epigastric pain, increased after food, and tendency to relaxation of the bowels: also in duodenal and biliary catarrh, and jaundice." Vertigo and vertiginous sensations connected with stomach-disorder, are often relieved by small doses of gold chlorides, but plethora and increased intracranial blood-pressure contra-indicate their use. On the other hand, they do good in cerebral anæmia, so that they may be prescribed when bromides would not be suitable. Melancholia and hypochondriasis with depression are often connected with gastric disorder and with cerebral anæmia, and are susceptible, to some extent, of relief by the same remedy.

Hemi-Anæsthesia.—I must not omit to notice the most modern application of gold as a remedy, and that is in its metallic form in "metallo-therapy," as developed mainly in Paris by Charcot and others. It seems that rather a large proportion of nervous patients on the Continent suffer from impaired sensation of one-half of the body, and that by the application of two metals, as a gold and a copper coin over several nerve-trunks, sensation may be "transferred," returning to the affected side in about a quarter of an hour, but often leaving, at the same time, the previously sound side. Such a peculiar circumstance is not yet wholly explained, but has been connected with a gentle galvanic action (Med. Record, 1878-79). Dr. A. Hughes Bennett and others explain the phenomena rather by "expectant attention," and I believe that mental influences of various kinds are a much more likely explanation than any specific properties of metals thus applied.

PREPARATIONS AND DOSE.—Fine gold, and the solution of the chloride, are placed in the appendix to the B.P., but no directions for their internal use are given. *Pulvis auri:* dose, $\frac{1}{4}$ to $\frac{1}{2}$ gr. gradually increased to 2 to 3 gr.—may be given in pill with confection of roses, but is not a good form. *Syrupus auri*, containing 24 gr. to the ounce, has been used by way of friction on the tongue, but cannot be depended upon. *Unguentum auri*, $\frac{1}{2}$ dr. to the ounce

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of lard—not dependable. *Chloride of gold and sodium:* dose, $\frac{1}{30}$ to $\frac{1}{10}$ gr. once or twice daily, in pill—the best preparation, but its irritant and poisonous properties should be remembered. *Teroxide of gold:* dose, $\frac{1}{10}$ gr. twice or thrice daily. *Iodide of gold* (French codex): dose, $\frac{1}{15}$ to $\frac{1}{10}$ gr., said to be more active than corrosive sublimate.

BARIUM, Ba, = 137·0.

A brilliant white metal, not met with in the native state but abundantly as the base of an alkaline earth, called *baryta* or *barytes* (an oxide), which occurs extensively as native sulphate ($BaSO_4$, heavy spar, its most common compound) and native carbonate (witherite).

BARYTA, BaO, = 153.

CHARACTERS AND TESTS—A greyish-white earthy-looking substance, heavy, sp. gr. 5·4, of sharp caustic taste and strongly alkaline reaction; sprinkled with water it becomes hot, and slakes with energetic action, falling into a fine white powder, = hydrate of baryta, BaH_2O_2, which contains 10½ per cent. water, and is soluble in 10 parts of boiling water. Baryta has, like lime, a strong affinity for sulphuric and carbonic acids.

BARII CHLORIDUM—CHLORIDE OF BARIUM, $BaCl_2 2H_2O$, = 244.

Is placed in the appendix as a test for sulphuric acid.

CHARACTERS AND TESTS.—Occurs in translucent soluble crystals, which have a bitter acrid taste. The solution gives with any soluble sulphate a heavy white precipitate, unaffected by nitric acid.

Carbonate of Baryta is a white insoluble powder.

ABSORPTION AND ELIMINATION.—We have no very accurate observations on these points, but Orfila detected the chloride of barium in the liver, spleen, and kidneys of animals poisoned by it (Annales d'Hygiène, ii., 1842).

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PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Small doses ($\frac{1}{12}$ to $\frac{1}{8}$ gr.) of the chloride exert a stimulant effect on the stomach-functions, increase the appetite, and often produce loose stools. Larger doses prove irritant or caustic; three grains, taken several times daily, soon induce a sense of pressure at the epigastrium, nausea, vomiting, and purging, with faintness (Fergusson, Dub. Journ., Feb., 1844). One drachm caused much vomiting and purging, and death from convulsion in seventeen hours (Walsh, Lancet, 1859). Half an ounce caused similar irritant symptoms, and death in two hours—evidence of severe gastro-intestinal inflammation was found (Taylor). The nitrate and acetate of baryta have also caused death, and the carbonate is commonly used as a poison for rats and mice. Although one teaspoonful is said to have destroyed life, much larger doses have been taken without fatal result.

Nervous System.—The nerve-symptoms caused by toxic doses of barium compounds, are clonic convulsions and motor paralysis, with impairment of reflex excitability. From the slow respiration observed in cases of poisoning, it has been concluded that the vagi become paralysed (Walsh). According to Cyon, the nerve-lesion caused is central, for even in advanced poisoning the muscular irritability and the sensibility of peripheral nerves remain intact (Reichert's Archiv, 1866, No. 2). Severe pains in head, throbbing in the temples, giddiness, dimness of sight, double vision, deafness, and tinnitus have been experienced: also muscular cramp, especially in the legs.

Circulatory System.—The heart-action is at first stimulated, afterwards quickly and powerfully depressed, by full doses of barium compounds. After some palpitation, the pulse becomes irregular, feeble, or imperceptible, and the surface cold and pale. Böhm concludes that they first stimulate, and then paralyse the automatic heart-ganglia. Onsum suggested that baryta compounds caused embolism by precipitation of the sulphates of blood (Virchow's Archiv, Bd. xxviii.), but Cyon has shown both that the normal sulphates exist in very small amount, and that if they are artificially increased, still no precipitate occurs on giving baryta (loc. cit.).

Glandular System.—We have not clear evidence of the

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effect of baryta on this system, but it is presumed to exert some absorptive "deobstruent" power on inflamed or hardened lymphatic glands. Small doses increase the secretion of urine and of perspiration (Waring).

SYNERGISTS.—Lime and other alkaline earths. The chloride of barium has some analogies with corrosive sublimate.

INCOMPATIBLES.—All sulphates are chemically incompatible with barium salts, forming insoluble compounds. The sulphates of soda and magnesia have been used as antidotes in cases of poisoning (Walsh), also white of egg and sugared wine (Perondi, Bull. de Thérap., t. x.).

THERAPEUTICAL ACTION.—*External.*—**Depilation.**—Dr. McCall Anderson recommends the sulphide of barium for removing superfluous hair, one part of it being made into a paste with four parts of zinc oxide and a little water; this should be left on the part for about three minutes, and then washed off.

Ophthalmia.—Dr. Pay recommended a collyrium of barium chloride (1 to 2 gr. in 10 oz.) in scrofulous ophthalmiæ (Rev. Med., 1840), but it is not now much used.

THERAPEUTICAL ACTION.—*Internal.*—**Scrofulosis, etc.**—Barium chloride was introduced at the end of last century as effective in scrofulous and syphilitic dyscrasiæ, in gonorrhœa, white swelling, etc. (Crawford, 1780). Lisfranc and Torget used it in such cases and in glandular tumours, and reported much advantage from it; the former began with $\frac{1}{8}$ gr. every hour, and increased the dose to much larger quantities than we should consider safe (40 gr.). In a child, many glandular tumours subsided under a month's treatment, but frictions with iodide of potassium were used at the same time (Amer. Journ., 1838, No. 45, Bull. de Thérap., 1840). Mr. R. Phillips recommended barium chloride as superior to iodine in many cases marked by pallor, languid circulation, and irritable mucous membranes (On Scrofula, 1846), and Mr. Balman used it in chlorotic and cachectic states generally (Med. Times, ii., 1851). In amenorrhœa he gave $\frac{1}{2}$ to 1-gr. doses with perchloride of iron. Many cases of successful treatment of scrofulous joint-disease, of ophthalmia, and of enlarged glands by barium

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chloride ($\frac{1}{12}$-gr. doses), were recorded some years ago (Ranking, 1846).

Epilepsy—Tetanus, etc.—Hufeland introduced this remedy for epilepsy in scrofulous subjects, but it is now seldom used. Brown-Séquard, however, whilst reporting against its efficacy, remarks that it may diminish reflex excitability, and therefore deserves trial in tetanus and in paralysis agitans. A somewhat doubtful case of traumatic tetanus is said to have recovered under the use of about 16 gr. of the chloride, given in twenty-four hours (Edin. Med. Journ., 1862). In satyriasis, or excessive sexual desire, it has also been employed. Dr. Hammond recommends it in diffuse and multiple cerebral sclerosis.

PREPARATIONS AND DOSE.—*Barii chloridum:* the dose mentioned by Dr. Garrod and others is from $\frac{1}{2}$ to 2 gr., but Mr. Kennedy, after much experience, maintains that $\frac{1}{16}$ to $\frac{1}{12}$ gr. is much more suitable and safer to commence with; very few persons, he says, can bear $\frac{1}{8}$ gr. without irritation (Lancet, ii., 1873, p. 28). The U.S. Pharmacopœia contains a *liquor barii chloridi* (1 part in 4 of distilled water); the dose ordered is 5 min.

As an *eye-lotion*, from 1 to 2 gr. may be ordered with 10 oz. of water. As a *depilatory*, 1 part of sulphide to 4 of excipient.

BISMUTHUM—BISMUTH, Bi, = 210—(MARCOSITA).

This substance, which is now, like antimony, classed amongst metalloids, occurs native, and also as an oxide, as a sulphide, and variously combined in metallic ores with silver, iron, copper, arsenic, etc.

PREPARATION.—The Pharmacopœia directs the preparation of a "*purified bismuth*," by fusion with nitrate of potash, but the process is not very satisfactory.

CHARACTERS.—The metalloid is grey-coloured with a roseate tinge, and may be obtained in masses of cubical,

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iridescent crystals; it is tasteless and inodorous, heavy, hard, brittle, and, like antimony, volatilizes at a strong heat, and expands on cooling.

BISMUTHI OXIDUM—OXIDE OF BISMUTH—BISMUTHOUS OXIDE—SESQUIOXIDE, Bi_2O_3, = 468.

PREPARATION.—By boiling the subnitrate with excess of solution of soda.

CHARACTERS.—A smooth, yellowish powder insoluble in water, presumed to be more definite in composition, and more constantly pure than other bismuth compounds (R. W. Smith).

BISMUTHI SUBNITRAS—SUBNITRATE OF BISMUTH—WHITE BISMUTH—SPANISH WHITE,
$Bi_2O_3 2HNO_3$, = 546.

PREPARATION.—The true *nitrate* (ternitrate), which is crystalline, soluble, and more active and irritant than the subsalt, is formed by dissolving the metalloid in nitric acid, and when this solution is poured into a large quantity of water it is decomposed, the *subnitrate* of bismuth falling as a white precipitate, and the supernitrate remaining in solution.

It was known as nitrate in an earlier Pharmacopœia, and is still sometimes described under that name (Ringer); it has been termed also trisnitrate, and hence some confusion between the properties of really different compounds.

CHARACTERS AND TESTS.—The subnitrate is crystalline, but when well prepared, should be in smooth and fine powder. It is heavy, whitish in colour, becoming yellowish-grey on exposure to light from the formation of some sulphide, or from the presence of silver; it is insoluble in water, soluble in nitric acid. It contains sometimes such an amount of acid as to effervesce when mixed with a carbonate (Martindale). A solution of bismuth subnitrate and sodium hydrate in water and glycerine is the Lowe test for sugar in urine: it has the advantage of being stable, and is recommended by Dr. W. G. Smith (B. M. J., ii., 1879).

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LIQUOR BISMUTHI ET AMMONIÆ CITRATIS—SOLUTION OF CITRATE OF BISMUTH AND AMMONIA.

PREPARATION.—By dissolving purified bismuth in nitric acid, and then adding citric acid and solution of ammonia until the precipitate at first formed is re-dissolved. (A better form for this preparation has been published—Pharm. Journ., 1866.)

CHARACTERS AND TESTS.—A colourless liquid, of saline metallic taste, miscible with water. Liquor potassæ precipitates the white hydrate, and hydrochloric acid the white oxychloride, but an excess of acid re-dissolves this as chloride. The officinal solution is described as neutral, or slightly alkaline, but it frequently contains an excess of nitric acid, much more than the original preparation of Schacht.

BISMUTHI CARBONAS—CARBONATE OF BISMUTH.

$2(Bi_2Co_6)H_2O$, = 1042.

PREPARATION.—By adding a concentrated solution of bismuth in nitric acid to an excess of carbonate of ammonia in cold solution.

CHARACTERS AND TESTS.—The salt which precipitates is a hydrated oxycarbonate, which is, like the subnitrate, insoluble in water, but is more soluble in the gastric juice, and has antacid properties.

On passing a current of sulphuretted hydrogen through an acid solution of a bismuth salt, the black sulphide of bismuth (Bi_2S_3) will be thrown down. Concentrated acid solutions of bismuth salts poured into water give a white precipitate of subsalt, *e.g.*, the nitrate when thus treated yields the subnitrate. Caustic alkali added to a solution of a bismuth salt precipitates the white hydrate of bismuth ($Bi_2O_3H_2O$). Papers saturated with sulpho-cyanide of potassium are coloured yellow by soluble bismuth salts.

ABSORPTION AND ELIMINATION.—Bismuth, in substance, is not absorbed by the skin, and the supposed instances of

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poisonous effects from its use as a cosmetic are not trustworthy (Husemann). A soluble bismuth salt, such as the ammonio-citrate, is, however, quickly absorbed from the cellular tissue after hypodermic injection.

Much difference exists in the degree of absorption of bismuth compounds taken by the mouth, and the difference is proportionate to their solubility. The acetate, the double tartrate, and the ammonio-citrate dissolve in the gastric fluids, and are readily absorbed, whilst the oxide and subcarbonate are but slightly soluble, and the ordinary subnitrate still less so.

Headland taught that it was as insoluble as charcoal, but Orfila and Lewald have detected the drug in the liver, in the milk, and the urine, after its administration, though in the latter secretion it appeared later than other metallic salts usually do. Bergeret and Mayençon detected it in the same fluids, and in the serous exudations of dropsy, and after giving small doses to rabbits they found it, within half an hour, in the blood, the spleen, the muscles, etc., and continued to find traces of it for eight days after administration. In one man they also found it five days after; in another, testing sixty-two days afterwards, they did not find any (Journ. de l'Anatomie, 1873). We may conclude, therefore, that some amount of absorption even of the subnitrate occurs (and probably as chloride), although the greater part of what has been taken has been found unchanged in the stomach in some cases, or altered to a bluish tint in the small intestine, or converted into the black sulphide in the colon or rectum, or has been eliminated with the fæces during life. Dr. Levick mentions a case of phthisical diarrhœa, in which 20 gr. were taken four times daily for some weeks, and the whole intestinal canal was found to be lined by the bismuth powder (Amer. Med. Journ., July, 1858). It is probable that more absorption occurs with small doses (such as the grain or less used originally by Odier, of Geneva), than with the very large ones (several hundred grains daily) prescribed by Monneret.

PHYSIOLOGICAL ACTION.—*External.*—The pulverulent bismuth compounds have an absorbent and protective effect: they are also somewhat astringent and sedative. The crys-

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tallized nitrate, especially when dissolved in glycerine, is also astringent, but is more irritating, even somewhat caustic.

PHYSIOLOGICAL ACTION. — *Internal.* — **Digestive System.**—Bismuth, taken in a pulverulent form, exerts upon the gastric mucous membrane a sedative, slightly astringent effect, similar to that already described as its external action. Taken in a liquid (more soluble) form, the effects are still of the same kind, but produced by smaller doses and with more tendency to irritation. Whether pure bismuth salts, when taken internally, can exert an irritant poisonous action, or are in the largest doses practically innocuous, has been much disputed. Orfila and Meyer, in experiments on animals, found that both the nitrate and the subnitrate, in doses of 1 to 2 dr., caused vomiting, tremor, depression, and death, with post-mortem evidence of gastro-enteritis (Toxicologie, ii., p. 10), and Wibmer, Wirkungen, etc., i., p. 423). Kerner also records a case of a man who took 40 gr. of the subnitrate, and suffered from gastric oppression, and burning pain, bitter taste, thirst, loss of appetite, eructation, griping, bilious vomiting and relaxation, with vertigo, dimness of sight, and headache—the pulse was small and tense; and another case—a man who swallowed 2 dr. (mixed with cream of tartar), and died after violent symptoms of irritant poisoning, such as burning pain in the throat, purging, vomiting, cramps, suppression of urine, tremor, and paralysis: after death, inflammation and even gangrene were found in the course of the alimentary tract (Wibmer, loc. cit.). Sobernheim subjoins to these cases, one that after a 2-dr. dose proved fatal in nine days, with similar symptoms, including also delirium and general swelling of the face, limbs, and abdomen: in this instance also, inflammation and gangrene of the stomach and intestines were found (Arzneimittellehre, 6th Ed., p. 265). Trousseau alludes to a similar case recorded by Pott in 1739, and Dr. Traill reports one where vomiting and pain followed the taking of 6 dr. (in divided doses). Christison describes "bismuth, in its saline combinations, as an active poison," and Taylor quotes some of the above cases as "proving that

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a substance very slightly soluble in water may exert a powerfully poisonous action on the human system."

On the other hand we must place the strong evidence of Trousseau and Monneret, and the daily experience of a majority of practitioners. Trousseau states that during a very extensive use of the well-prepared subnitrate in doses of from 15 to 60 gr., he has never seen the slightest accident, or the least cause for apprehension (Mat. Med., i.), whilst Monneret prescribed the enormous doses of 150 up to 900 gr. per diem, without any inconvenience resulting. He noted only slight constipation with lessened odour and blackened colour of the fæces; there was no thirst, nausea, or pain, nor any evidence of inflammation, and the appetite was rather increased than diminished. Such doses as the above are not likely to be now prescribed, but many physicians order 10, 20, or 30 gr. several times daily without any evil result.

Trousseau and others explain the toxic symptoms above noted by the presence of *arsenic* as an impurity, and in some cases correctly, as shown by Taylor. H. C. Wood also records a case of bloody purging from the use of an adulterated drug, and the effects are certainly those of an irritant poison. Still, as a rule, there is no evidence of the requisite amount of arsenic for serious results, even in the most adulterated specimens of bismuth. Stillé speaks of one-sixth of 1 per cent. as the maximum proportion found, whilst Parral and Garnier ascertained that preparations containing 0·129 per cent. did not poison dogs, even in doses of 200 to 500 gr. (*see* also Adulteration).

Monneret suggested that in the above cases, either a previous illness became suddenly exaggerated, or an excess of *soluble nitrate* acted as an irritant: the last alternative seems possible after recent evidence, that soluble compounds of bismuth have an activity hitherto not supposed in pure preparations. The acetate (according to Bricka), the double tartrate (Rabuteau), and the ammonio-citrate (Stephanowitsch) given in large doses, produce poisonous symptoms very like those of the allied metals, gold and quicksilver. Rabuteau "at first held the classical opinion as to the remarkable harmlessness of bismuth," but his observations with the double tartrate, or "emetic" of bismuth and potash ($C_4H_4K(BiO)O_6$) have convinced him that *slight solubility* explains the general absence of dynamic

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effects after large doses of the ordinary preparations. The tartrate is soluble in water without decomposition, and gives a metallic taste like that of ordinary "tartar emetic," it causes vomiting, and 30 to 60 gr. prove fatal to small dogs. In connection with this observation, it is noteworthy that in Kerner's fatal case, the patient took cream of tartar with his dose of bismuth, and the salt referred to by Rabuteau would probably be formed. Stephanowitsch records of the ammonio-citrate that its hypodermic injection, in the proportion of 1 gramme to each 1,000 grammes of body-weight, will kill animals, and that salivation and buccal abscess follow its use, as well as steatosis of liver, kidneys, and heart. The liver glycogen disappears under its prolonged administration (Lebedeff).

Although, therefore, some of the older cases were connected with the presence of arsenic, yet bismuth cannot be held entirely innocuous, and its activity clearly depends upon its solubility. The oxide, the subcarbonate, and subnitrate, though but slightly soluble, may be taken up to some extent, especially when small doses are used. Thus, Odier, of Geneva, gave only a few grains, or less than a grain, and noticed occasionally vomiting, diarrhœa, a sense of heat, vertigo, and drowsiness. M. Guersant has noted colic and "sense of anxiety," and Rabuteau some general sedation, like the effect of antimony, and I have observed some clinical evidence in the same direction; but the existence of a chronic form of bismuth poisoning, marked by anæmia, swelling of gums, hæmorrhage, etc., as described by Lussanna in man,[1] and by Stephanowitsch in animals, has not been further verified. The only observation bearing upon it that I have found is one by Dr. Brinton, who states that if the subnitrate be taken continuously it will cause a bluish-red line on the gums, "similar to, but wider and more red than that known to be caused by lead" (Diseases of Stomach, 1st Ed., p. 197). I have

[1] Dr. Lussanna remarks that Monneret's results with large doses "have destroyed the Orfilian scarecrow," but his own conclusions are almost as alarming as those of Orfila. From large doses, used apparently chiefly in tuberculous diarrhœa, he witnessed no irritation, nor any arrest of the malady, but supervention of a "colliquative and scorbutic state," connected, he presumes, with a solvent action on globulin—he traces a profuse epistaxis in a case of mesenteric tuberculosis to the use of bismuth, but gives no sufficient details of the cases on which his exceptional conclusions are based.

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not found this noted by any other observer, but lead has been suggested as an adulterant in the preparations used by Lussanna.

The action of *Liquor Bismuthi* differs somewhat from that of the solid compounds, and probably represents rather the real activity of the drug, independently of the mechanical effect of a powder; it is more irritant (H. Wood), and it has failed to relieve gastric pain when the subnitrate has succeeded (Macnamara). The carbonate is said to be less liable to irritate than the subnitrate, and yet to be more soluble in the gastric juice (Hannon); it does not perhaps absorb intestinal gases so readily as the subnitrate or oxide, but has better antacid powers, and is not so likely to constipate. The observer named, traced to it also some primary sedative effects, like those described by Rabuteau of the nitrate, viz., weakening and slowing of pulse, lessened appetite, and increased excretion of urine, but found that its continued use improved strength and vigour like iron preparations.

SYNERGISTS.—Mechanical absorbents and antacids and sedatives. Magnesia is specially suited for combination with bismuth salts.

INCOMPATIBLES.—Acids are said to be incompatible with the subnitrate of bismuth (Gubler), and some have advised the omission of all acids from the diet during its administration. Practically, however, their effect is only to favour the production of the more soluble nitrate, which should, in suitable dose, act favourably without discomfort, and a few minims of nitric acid are not infrequently prescribed with it; they should be omitted, however, if a merely protective effect is desired from an insoluble preparation. Bismuth prescribed with a strong solution of iodide of potassium precipitates as a red iodide, which is insoluble and apparently inactive (B. M. J., ii., 1870).

THERAPEUTICAL ACTION. — *External.* — **Erythema, Eczema, etc.**—In these and allied forms of congestive and inflammatory skin-disease, bismuth compounds are often extremely useful, by virtue of their absorbent, astringent, and soothing properties. In erythema and erysipelas, intertrigo,

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and bedsore they may be applied in powder, alone or diluted with starch or magnesia, or made into a cream with water and glycerine, or into an ointment in the proportion of 30 to 120 gr. in the ounce of prepared lard, cold cream, or vaseline. (Dr. McCall Anderson, in praising this ointment, notes that it should not be made with *benzoated* lard, or else, for some unexplained reason, it becomes liable to irritate.) An oleate of bismuth is also a good preparation: according to Dr. Louis Lewis, oleic acid may be made to take up 20 per cent. of oxide (Pharm. Journ., Dec., 1876).

In the acute stages of eczema, when there is much irritability and much serous discharge, these preparations are also very serviceable; they seem to be sufficiently astringent, yet not so much so as lead, zinc, or tannin, and will often act better than those remedies. In later stages, when there is infiltration with redness and scaliness, a stronger solution of the soluble nitrate in glycerine becomes suitable.

In the erythema connected with acne of the face, bismuth forms a good ingredient in soothing lotions: a small quantity of corrosive sublimate (2 gr. to 8 or 10 oz. of liquid) is often combined with great advantage, when sulphur and other stimulants could not be borne.

As a cosmetic under the name of "blanc de perle," bismuth salts have long been celebrated: they are liable to become darkened by contact with sulphur in any form (*e.g.*, the sulphuretted hydrogen of ordinary gas, etc.), some proportion of the black sulphide being generated.

For chaps, and fissures about the hands, lips, nipples, etc., bismuth ointment is very good, and especially with a little tincture of benzoin (20 to 30 min. to 1 oz.). Trousseau specially commends it for anal fissure (Bull. de Thérap., v., p. 63), and others for ulceration of the septum nasi, and excoriations of the cervix uteri. Follin used a glycerole, containing 1 or 2 parts in 3 of the liquid, for chronic granular conjunctivitis.

Catarrh—Chronic Discharges.—Monneret recommended the insufflation of bismuth powders for coryza, and in chronic catarrhal conditions Soubrier used a snuff containing 4 parts of the subnitrate with 8 of liquorice and 30 of iodide of

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sulphur (Bulletin, 1859). For acute cases Dr. Ferrier has lately re-introduced a formula containing ½ to 1 gr. of morphia, well triturated with 60 gr. each of the subnitrate and of gum acacia, and this often acts well in cutting short a troublesome "cold in the head;" this I have frequently prescribed, but find patients discontinue it on account of its causing frontal headache and clogging of the nostrils. In leucorrhœa, bismuth has been applied in powder or paste, on charpie, or as injection in the proportion of 1 to 8 of water, and has been used with advantage in gonorrhœa and gleet (Caby).

THERAPEUTICAL ACTION. — *Internal.* — **Dyspepsia.**— According to Monneret, "pain arising during digestion, from whatever cause," may be relieved by mixing the subnitrate freely with the food, but more definite indications may be given. Gastric pains dependent on indigestible food, marked constipation or hepatic congestion, require emesis or purgation, whilst in vomiting connected with fermentation of food, dilatation of stomach, etc., antiseptic remedies and perhaps washing out of the viscus may be necessary.

Bismuth is specially indicated in cases of difficult digestion with tendency to diarrhœa, in subacute or chronic gastritis, and gastralgia with marked irritability of mucous membrane: for such cases, Odier first introduced it (in Geneva, 1786); he describes severe gastric pain as frequent amongst the servants there who lift and carry on their heads large vessels of water— the pain was either spasmodic, sudden, intense, and relieved by pressure, or more persistent and accompanied with sensations of gnawing, sinking, and pulsation; eructation, nausea, and vomiting occurred in greater or less degree, and the general health and mental state became much depressed. Such cases were much relieved by bismuth in moderate doses; and Marcet, Bardsley, and other English physicians have published similar experiences.

Nothnagel finds it especially useful when pain occurs after food in badly-nourished over-worked persons; but when there is marked anæmia or a general neuralgic condition it is not so

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serviceable alone, nor is it very permanent in its good effects. Prussic acid, or opium, alkalies, and later iron and bitters, may be conjoined with it. Caizergues especially praises a combination of 4 gr. with $\frac{1}{3}$ gr. of extract of belladonna in the gastralgia of chlorosis (Lond. Journ. Med. Sci., 1851).

When *acid pyrosis* is a marked symptom, bismuth is particularly indicated either alone, or, if acidity be marked and constipation usual, then combined with magnesia. According to Trousseau, if the rejected fluid be insipid, glairy, or sour ropy phlegm, bismuth alone is contra-indicated, but in most cases it deserves trial, requiring only that constipation be remedied. The nausea and vomiting of gastric irritation is commonly amenable to bismuth, *reflex* vomiting, such as that of pregnancy, not so (Husemann); this is an argument in favour of the local protective effect of the drug.

In *infantile vomiting*, which is frequently dependent on acidity or ill-digested food, and accompanied by diarrhœa and pain, bismuth is exceedingly useful, being, as it is, practically harmless and tasteless—1 to 2 gr. may be placed on the infant's tongue with a moistened finger. A minute dose of creasote, $\frac{1}{10}$ of a drop, may often be usefully combined (B. M. J., ii., 1875).

In **Ulceration of the Stomach**, when pain is very severe and exhausting, and when vomiting is frequent, much relief may be given by full doses; and I have noticed that distressing thirst has been rather relieved than increased by the remedy. Dr. Brinton attached great value to it; it is often given with opium in such cases.

In **Malignant Disease** even, I have found bismuth palliate for a time the most severe symptoms; and in both these conditions it acts mainly by forming a smooth layer over exposed and hyper-sensitive nerves, and so preventing the contact of food and unhealthy secretions: to obtain such a result it is evident that more than ordinary doses are required.

Gastro-Uterine Irritation.—Trousseau undervalued the virtues of bismuth when he held it unsuited for gastric pain connected with leucorrhœa. It has really a special sphere of action in various uterine disorders which induce or follow on gastric derangement, as has been well shown by F. W. Mackenzie (Lond. Journ. Med.,' 1857). His cases seemed to prove the

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stomach primarily at fault, since complaint was made of pain, sinking, flatulence, etc., before the ordinary symptoms of uterine irritation appeared; bismuth greatly relieved them, and my own experience is somewhat to the same effect. In dysmenorrhœa, with severe pain in the back, hips, legs, and hypogastric region, palpitation, etc., I have often given it with good effect, and in uterine hæmorrhage (profuse menstruation) it has proved strikingly efficacious when recognized styptics had failed, being thus allied in action with oxide of silver and arsenic; apparently a sedative influence is exerted both on the stomach and the uterus through the mucous tract and connected nerve-ganglia.

Diarrhœa.—In irritative diarrhœa, with red tongue, nausea, heartburn, griping pain worse after meals, and frequent ill-formed stools, I have found bismuth invaluable. In some persons, mostly women, such a condition becomes habitual, and even ordinary articles of diet may cause severe aggravation of symptoms; the constant use of this remedy, however, gives them the greatest relief, and enables them to take food with comparative comfort; much flatulence is often present, and sometimes the diarrhœa depends on irritation from the development of sulphuretted hydrogen (Chambers). Bismuth is then also very suitable, for it combines readily with that gas and absorbs it (Practitioner, 1869); sometimes charcoal, or aromatic chalk powder, or rhubarb, may be added with much advantage.

Infantile Diarrhœa.—When infants at the breast suffer from eructations, sour vomiting, diarrhœa, light-coloured papescent stools of bad odour, with crampy pains in the stomach, I have always found bismuth act well. In that form of diarrhœa which so readily affects children whilst being weaned, or during hot weather, or that which continues even after irritation has been removed, it is also of great service; from 1 to 5 gr. may be given several times daily to children of one year and under. Weller prescribed for children as much as 30 to 60 gr. of subnitrate every hour (interdicting milk during the treatment), with no other than good results (Deutsches Archiv, quoted Amer. Journ., 1870).

The *ulcerative diarrhœa* and aphthous condition connected with

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phthisis is alleviated by full doses. Traube (one of the first to recommend the remedy in such cases) supports the view of its acting mainly as a mechanical protective, lessening local irritation, and consequently reflex peristalsis. We have already referred to a case in which the powder was found to line the whole tract, and it is evident that for such protective effect large doses are necessary. Dr. T. Thompson, who prescribed about 5 gr. of the subnitrate with magnesia and mucilage, and Monneret, who gave many drachms for a dose, are strong advocates of its advantages. The latter observer states that he had seen many persons who were apparently dying with tuberculous diarrhœa, restored for a time to comparative health (Med.-Chir. Trans., v., p. 31, and Bulletin, v., p. 47), but the results of others have not been so favourable. The persistent diarrhœa of enteric fever is sometimes well treated in the same manner.

Dysentery.—M. Brassac, of the French naval service, records the best results from bismuth in epidemic dysentery. Finding little or no benefit from small doses, he followed the teaching of Monneret, and beginning with 230 to 300 gr daily, increased to more than 1,000 gr.; he divided this into about five doses, according to the case, giving it in broth or milk, or sometimes by enema, and so long as more than one stool occurred in the day. This plan was very successful, and had no ill result; as a rule, his patients began at once to eat better and to gain strength (quoted Edin. Med. Journ., 1867). Trousseau also used bismuth injections in dysentery (Lancet, i., 1855), and more recently Dr. Houghton writes from Borneo, concerning their great value in subacute and chronic cases in tropical climates; he prescribes 30 gr. with mucilage to be injected two or three times daily, and retained if possible (Lancet, ii., 1879). In acute and chronic colitis, Lasèque also used, with the best results, enemata of 30 to 150 gr. with egg or mucilage.

Cholera.—In the epidemic at Warsaw, in 1831, it was highly approved by Leo, and in later epidemics at Paris it was commended by Trousseau, and very largely used for the premonitory diarrhœa; at the commencement of the attack only, a little opium may be added with advantage; afterwards, two full doses of bismuth daily will suffice.

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The reputation which has been sometimes claimed for bismuth as a valuable remedy in intermittent fever, and in nervous disorders, as epilepsy, cephalalgia, asthma, and in whooping-cough, must be traced either to its relieving gastric complications of such maladies, or to the presence of contained arsenic: it has not been sustained in recent times.

PREPARATIONS AND DOSE.—*Bismuthi oxidum:* dose, 5 to 15 gr. or more. *Bismuthi subnitratis:* dose, 5 to 20 gr. or more (see below). *Trochisci bismuthi:* dose, 1 to 6 lozenges (each lozenge contains 2 gr. with lime and magnesia). *Liquor bismuthi et ammoniæ citratis:* dose, ½ to 1 fl. dr. and upwards (contains 3 gr. of oxide in each fluid drachm). The preparation of Schacht is said to contain only 1 gr. of oxide in each drachm: dose, 1 to 4 dr. *Bismuthi carbonas:* dose, 5 to 20 gr. or more.

Preparations of bismuth should be taken about a quarter of an hour before, or with meals, and if a mechanical protective effect is most desired, acids are better avoided during the medication.

Subnitrate.—The dose should depend upon its molecular state. Thus, if it be very dry and likely to become caked together in the stomach, very large doses may not act at all, or may cause irritation, whilst if moistened or formed into hydrate, or carefully mixed with some other fine powder, moderate doses will give a much better result. Thus, Quesneville took 80 grammes without much advantage, but afterwards using the drug thoroughly soaked in water, soon obtained good effects with 5 to 10 grammes; his "*bismuth-cream*" is a valuable preparation, better known abroad than in this country. Doses of 1½ to 2½ dr. are now seldom used, 5 or 10 gr. representing an average prescription for adults. Much more may, however, be given in organic disease when there is erosion or ulceration of the alimentary surface; milk or almond emulsion is a good vehicle. The subnitrate forms a part of the "*poudre de Wendt,*" also of the powder of Robert Thomas; combined with magnesia it is "Patterson's, or American powder," and with pepsine, the "*poudre de Royer.*"

The liquor bismuthi and ammoniæ citratis are miscible with

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water and spirit, but not with alkalies without precipitation. The so-called "lac bismuthi" (Symes) contains the hydrate mechanically suspended.

A lactate, a tannate, and a valerianate of bismuth have been described: the first is a soluble salt, and may be given in small doses; the compound with tannin is designed to favour its astringent, and the valerianate any nerve-tonic powers. A citrate of iron and bismuth is sometimes useful.

Besides these, there are many private preparations, as of bismuth and pepsine, bismuth and strychnia, etc.

A glycerole of the neutral nitrate is best prepared by dissolving ½ oz. of the crystallized salt in 2 dr. of pure glycerine and an equal quantity of distilled water, afterwards adding glycerine to 6 oz. *Unguentum bismuthi* may be prepared with ½ to 1 dr. of any bismuth salt in 1 oz. of cold cream (not benzoated). An *oleate* is made with oleic acid and the oxide in strengths of from 10 to 20 per cent. A lotion or injection is made with 1 part to 8 of liquid. Pessaries are made containing 15 gr. in each.

ADULTERATIONS.—Besides being variable in its chemical constitution, in the amount of oxide and of acid present, the subnitrate may contain added carbonate, and phosphate of lime, carbonate of lead, sub-chloride of bismuth, and other metals introduced in the process of manufacture, also certain natural impurities not removed—*e.g.*, traces of iron, copper, silver, and arsenic. The last is the most important, although no official test for its presence in bismuth is given. In the older preparations it was probably always present, and so long ago as 1743, Geoffrey expressed his fear of bad results from it (Materia Medica). In later times, Dr. Taylor found it in three out of five specimens; and Mr. Edin found it in many specimens of liquor bismuthi when it was first introduced (Pharm. Journ., 1868).

The practical bearing of such adulteration was illustrated in a trial for arsenical poisoning at Philadelphia about twenty years ago. It was proved that bismuth "nitrate" had been prescribed shortly before death: a specimen of the particular salt dispensed could not be found, but of ten others purchased in the

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city, a majority contained arsenic, and although the irritant symptoms had commenced before bismuth was prescribed, and the proportion of arsenic found in the viscera was much more than bismuth adulteration would account for, yet the trial was stopped, and the accused person discharged (Amer. Med. Journ., July, 1858).

At the present time, however, adulteration with arsenic is exceptional. Of six chance specimens examined under the direction of Dr. Anstie, not one contained it (Practitioner, 1871); and Prof. Siebold, after much experience, reports that it is now rarely found (Pharm. Journ., Dec., 1875). Of seven samples of the basic nitrate of the American codex, one only contained arsenic—·33 per cent. (Op. cit., Nov., 1875). In the oxide he often found traces of sodium and lead, and commonly subchloride and subnitrate.

Selenium and *tellurium* have been found in some specimens of bismuth salts, and a Colorado ore of the metalloid has been found to contain 34 per cent. of tellurium. This may explain the offensive alliaceous odour which is sometimes given to the breath by special samples of bismuth preparations. It resembles that of arseniuretted hydrogen, and has naturally been attributed to that gas, and yet not correctly; and the absence of the poison in certain offending samples has been proved by analysis (Pharm. Journ., Dec., 1875); neither can the odour be traced to prussic acid or other usual ingredients in bismuth mixtures: whilst we know that tellurium can impart an offensive odour, for Sir James Simpson made trial of the drug, and Dr. Maclagan relates that on one occasion a student took a dose which obliged him to sit apart from the class for the rest of a session! (Edin. Med. Journ., Dec., 1854).

The carbonate of bismuth is liable to contain chlorides, also sodium, and sometimes lead. In five specimens examined by Prescott no arsenic was found (Pharm. Journ.).

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CADMIUM, Cd, = 112.

This is a somewhat rare metal, found associated with zinc in nearly all its ores, and obtained from these by distillation.

CHARACTERS AND TESTS.—Tin-white and lustrous, fibrous in fracture, ductile and malleable, of sp. gr. 8·6 to 8·9. In air, at ordinary temperatures, it tarnishes gradually; heated strongly it takes fire, and burns to a brown oxide, CdO; at 176° F. it becomes very brittle, and fuses at 442° F. Treated with dilute mineral acids, it sets free hydrogen, and forms a colourless solution; this, when further diluted, gives with sulphuretted hydrogen a bright yellow precipitate of cadmium sulphide (CdS), insoluble in ammonium sulphide. Caustic and carbonated alkalies give with cadmium salts gelatinous white precipitates, which, except in the case of ammonia, are insoluble in excess. Zinc precipitates metallic cadmium.

CADMII IODIDUM—IODIDE OF CADMIUM, CdI_2, = 366.

PREPARATION.—By the direct combination of the metal with iodine in the presence of water.

CHARACTERS AND TESTS.—Occurs in flat, micaceous white crystals, of pearly lustre, which melt at 600° F. into an amber-coloured fluid; they are anhydrous, permanent in air, but decompose at a dull-red heat, with evolution of iodine in vapour. In water and spirit they are freely soluble, the solution being acid to test paper, and answering to the tests for cadmium already mentioned.

The Sulphate of Cadmium is officinal in the United States. It occurs in oblique, rhombic prisms, translucent and colourless, like those of zinc sulphate; it has an acid, astringent taste, effloresces on exposure, and dissolves readily in water.

The Bromide of Cadmium resembles the analogous salt of ammonium, and has been taken by mistake for it; it is used in photography.

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ABSORPTION AND ELIMINATION. — Cadmium salts coagulate and combine with albumen, but these albuminates dissolve in an excess of the salt, especially in excess of a double salt, such as the chloride of cadmium and sodium; even in alkaline chlorides they are partially soluble, so that we can readily understand their absorption from the stomach. Absorption occurs also after their injection into the cellular tissue, the bowel, etc., as evidenced by the finding of cadmium compounds in the organs and secretions (Marmé, Schmidt's Jahrb., iii., 1867).

Elimination of the drug begins soon after its administration, and takes place mainly by the kidneys.

PHYSIOLOGICAL ACTION.—*Internal.*—Digestive System.—Cadmium compounds, except the sulphide, resemble each other in action. The sulphide, though considered poisonous by van Hasselt, has been given to animals in drachm doses daily for a week, without evident effect, and is therefore pronounced inert by Marmé. The oxide, chloride, sulphate, iodide, etc., given in doses of ½ to 2 gr., cause pain at the epigastrium, vomiting, and purging, and in somewhat larger doses gastro-enteritis, which may pass on to ulceration. Similar effects follow their hypodermic injection, and after toxic doses given in this manner, the gastro-intestinal mucous membrane has been found inflamed; irritation and suppuration also occur at the site of injection. The continued administration of small doses induces a chronic form of poisoning marked by dyspepsia and emaciation, which in animals has terminated in death from exhaustion. In the case of two ladies who took by accident a quantity of bromide of cadmium (not less than 5, or more than 16 gr.) pungent taste and sensations in mouth and throat were felt, and burning pain at the epigastrium, vomiting and purging set in, and continued for five hours, and after recovery the stomach remained very irritable (Wheeler, Boston Med. Surg. Journ., Oct., 1876). In a man who took 9 gr. of a cadmium salt, salivation, colic, and catharsis followed in the course of an hour, and four hours afterwards, violent vomiting, gastralgia, and tenesmus (Burdach). In a dog, death has followed the in-

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jection of $\frac{1}{6}$ to $\frac{1}{3}$ gr. into a vein, or the giving of 5 to 9 gr. by the mouth.

Nervous and Circulatory Systems.—Foret has described, in cases of poisoning by cadmium carbonate, besides the symptoms of gastric irritation—giddiness, prostration, loss of consciousness, cramp, and slowing of respiration and heart-action. In the ladies above mentioned, somnolence was marked after subsidence of the irritant symptoms.

SYNERGISTS.—Salts of zinc and lead.

ANTIDOTES.—In acute poisoning by cadmium salts, the alkaline carbonates with albumen (white of egg) are the best antidotes. In Marmé's experiments, injections of dilute soda solutions into the stomach soon after the exhibition of the poison quite prevented bad effects.

THERAPEUTICAL ACTION.—*External.*—The only officinal salt, the iodide, is used in the form of ointment in glandular scrofulosis, and has been recommended by Guibert and Garrod. Other physicians have prescribed it in splenic enlargement and in strumous skin-disease (Waring). I have used it repeatedly in cases of enlarged glands, of nodes, and of chronic joint-inflammation, with satisfactory result. It does not stain the skin, like iodide of lead, but is liable to cause irritation unless diluted.

In Ophthalmic Surgery cadmium sulphate has been used more as an astringent in lotion or ointment for dyscrasic inflammation of the eye, and for corneal opacities (leucoma), (Gräfe, Kopp, Middlemore).

THERAPEUTICAL ACTION.—*Internal.*—The sulphate of cadmium has been recommended in syphilis, rheumatism, and gout (Grimand), but there is, at present, little evidence of its special powers.

Gonorrhœa—Leucorrhœa.—In these maladies injections of sulphate of cadmium have been used by Lincke, but possess no evident advantage over injections of sulphate of zinc.

PREPARATIONS AND DOSE. — *Unguentum cadmii iodidi* (contains 62 gr. in 1 oz. of simple ointment). *Cadmii sulphas:*

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as much lime is dissolved as at 212° F. At ordinary temperatures water dissolves only about ½ gr. to the ounce, but its solvent power is increased by syrup or by glycerine to the extent of nearly 8 gr. to the ounce. Lime does not melt at the highest temperature, and hence its use for the electric and oxyhydrogen lights; sp. gr. 2·078.

The chief test for lime is the white precipitate formed with oxalate of ammonium, insoluble in acetic acid, but soluble in hydrochloric or nitric acid. Lime readily absorbs carbonic acid, the presence of which is detected by effervescence with acids. (This power of absorbing CO_2 has been utilized by Liebig to purify close rooms, for lime placed in them will, by such absorption, create a partial vacuum, to supply which air passes in through crevices. The same absorptive power partly causes the dampness of a new house, for the lime of mortar absorbs the carbonic acid of the air and the breath, leaving the moisture to condense on the walls).

The *Liquor Calcis* of the Pharmacopœia is a solution in water containing about ½ gr. to the ounce (that being its point of saturation). It is prepared by digesting slaked lime in eighty times its weight of cold water for some hours, and is a colourless liquid when recently made, but on exposure to air, or if breathed into, an insoluble carbonate readily forms and precipitates. If warmed, the liquor calcis becomes turbid from deposition of some of the lime. It forms an ingredient in the black and the yellow "mercurial wash."

Liquor Calcis Saccharatus.—Saccharated lime-water is prepared by mixing slaked lime with twice its weight of sugar, and digesting in water for a few hours; it becomes yellowish by keeping; its taste is more caustic and unpleasant than that of the simple liquor; it contains 7·11 gr. of lime per ounce.

Linimentum Calcis is an emulsion or soap formed with equal parts of lime-water and olive oil, and containing an oleate of calcium.

CALCIS CARBONAS—CARBONATE OF LIME,

$CaCO_3$, = 100.

Three forms are officinal: (1) *Creta*—chalk—the native, friable, and not pure carbonate; (2) *Creta preparata*—prepared chalk—

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the same substance well washed, or "elutriated," after being reduced to fine powder; and (3) *Calcis carbonas præcipitata*—precipitated carbonate of lime.

1. *Ordinary chalk* is used only to produce carbonic acid gas in the making of carbonates, etc.

2. *Prepared chalk* occurs either in white powder or in small conical masses. The process of "elutriation" consists in treating the powder with a large quantity of water, allowing it to stand for a time, decanting from heavy particles, and allowing the milky liquid to gradually deposit—this form is used in mistura cretæ and pulvis cretæ aromaticus.

3. *Precipitated* carbonate of lime is prepared by mixing a solution of carbonate of soda in excess, and at a boiling temperature, with solution of chloride of calcium. Carbonate of lime and chloride of sodium are formed, and the precipitate is washed until all the latter salt is removed. This preparation being crystalline and somewhat gritty, constitutes an ingredient of tooth powders, but is not otherwise recommended except in bismuth lozenges.

CALCII CHLORIDUM—CHLORIDE OF CALCIUM, $CaCl_2 6H_2O$, = 219.

PREPARATION.—By neutralizing hydrochloric acid with chalk or white marble, and adding to the solution a little chlorinated lime and slaked lime. In the first process carbonic acid is evolved and chloride of calcium formed:

$$2HCl + CaCO_3 = CaCl_2 + CO_2 + H_2O.$$

In the second process the added lime frees the solution from iron and magnesia; it should then be filtered and evaporated to dryness at a temperature of 400° F. If the solution be simply evaporated, the chloride is left combined with water $CaCl_2 6(H_2O)$, and it is only at a heat sufficient to fuse the mass that it parts with all its water.

CHARACTERS AND TESTS.—This salt has a great absorbent power for water, is deliquescent, and very soluble; it occurs in crystals, or in whitish crystalline fragments of bitter, acrid, saline taste. It must be distinguished from

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calx chlorata (chloride of lime), and does not, like that compound, evolve chlorine on addition of hydrochloric acid.

CALX CHLORATA—CHLORIDE OF LIME—CHLORINATED LIME.

PREPARATION.—By saturating moist slaked lime with chlorine gas—$CaH_2O_2 + 2Cl = H_2O + CaOCl_2$—but as to its exact constitution there is still some difference of opinion. Many chemists, following Balard, consider it to be a mixture of chloride and hypochlorite of calcium, which would correspond to the above formula *doubled;* thus, $2CaOCl_2 = CaCl_2 + CaCl_2O_2$, and this, with the addition of two atoms of water, is the formula adopted by Garrod.

CHARACTERS AND TESTS.—Occurs in whitish powder or lumps, having the odour of chlorine, and an acrid, caustic taste; if it contain much chloride of calcium it will be moist. It is unstable in composition, readily giving off chlorine when exposed to the air, and being decomposed by any acid. When pure it is wholly soluble in water, but it generally contains some free hydrate, and is only partially soluble. It has powerful deodorant and bleaching properties, which depend on the presence of chlorine, and the purity-test is directed to estimating the amount of this gas (chlorimetry). Thus, by adding hydrochloric acid to chlorinated lime, chlorine gas is liberated, and this being brought into contact with iodide of potassium sets free an equivalent amount of iodine, which is estimated by hyposulphite of sodium.

Liquor Calcis Chloratæ—Solution of Chlorinated Lime—contains about 13 gr. of available chlorine to each fluid ounce of water.

Vapor Chlori—Chlorine Inhalation.—Prepared by moistening 2 oz. of chlorinated lime with cold water in a suitable apparatus (*v.* p. 160).

CALCIS PHOSPHAS—PHOSPHATE OF LIME.

Officinal in two forms: (1) *os ustum*—bone-ash; (2) *pure tribasic phosphate.*

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PREPARATION.—(1) *Os Ustum.*—When bones are calcined in *close* vessels, the residue consists of earthy salts mixed with charcoal (carbo animalis); but when calcined in *open* vessels, all animal and carbonaceous matter is burnt off, and the white friable residue consists mainly of phosphate and carbonate of lime (bone-earth, bone-ash). This, when treated with hydrochloric acid, and afterwards with ammonia, is changed into (2) *tribasic* (or tricalcic) *phosphate*, $Ca_3 2(PO_4)$, which is washed and dried at 212°, and forms a crystalline white powder, insoluble in water, soluble in acids. It has been found to contain lead (Duquesnel).

This form is the one most commonly found in nature, sometimes almost pure (phosphorite) or in friable masses, like chalk (osteoliths), or in the fossil fæces of ancient saurians (coprolites), in shells and sedimentary earths. From the soil it is absorbed by plants, by the help of water and carbonic acid, and is determined specially to the *seed*. From plants it is received by herbivorous animals, and in *their* flesh and blood and bone it is sought by the carnivora. It has been said that the amount of phosphate of lime found in different animals is proportionate to the *activity of their movements* (Dusart and Blache). (The salt was obtained formerly for medical use from the excrement of dogs when hard and white, as it is passed after they have eaten many *bones;* it was known as "album græcum.")

Besides the tribasic phosphate there are two others, a *neutral* and an *acid phosphate.* The former, $Ca_2H_2 2(PO_4)$, is a white, crystalline powder, tasteless and insoluble; it occurs in some (carbonated) mineral waters, and may be prepared by mixing neutral phosphate of soda with chloride of calcium. The *acid phosphate*, $CaH_4 2(PO_4)$, is very soluble, and even deliquescent, and is left in solution when sulphate of lime is precipitated after treating bone-ash with sulphuric acid.

ABSORPTION AND ELIMINATION.—The various salts of lime differ somewhat as to their absorption and their action. The *tribasic* and *neutral phosphates*, in small doses (less than 5 or 6 gr.), with but little water, are wholly absorbed under the influence of the acid gastric secretion; but if given with much water, the acids are so far diluted that they do not act upon the

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insoluble drug, and it passes off mainly by the fæces. If large doses be given, the greater part passes out unchanged.

Gouriet has suggested that the solubility necessary for securing the absorption of lime phosphate is effected partly by means of the phosphate of soda contained in the saliva, partly by the phosphate of ammonia and the acids in the gastric juice; when it has passed into the veins, solubility is still further assisted by the carbonic acid present in venous blood. During respiratory combustion, when carbonic acid is given off and lactic and other acids altered, the phosphate that has been taken is only retained in solution by the help of the normal alkaline phosphates of the blood: if these be in small proportion the lime salts become soon deposited (more in bone than in other tissues), and little passes in the urine; if, however, in any given case the alkaline phosphates be in excess, then most of the lime salt is retained in solution in the blood until it is (mainly) excreted through the kidneys (Lancet, ii., 1860, p. 251). This explanation seems rather too chemical, and it must be compared with the important observations more recently made by Paquelin and Jolly. They conclude that the tribasic phosphate of lime is not acted upon in the stomach, unless it be by part becoming super-phosphate, and this again is precipitated in the intestine under the influence of alkaline biliary and pancreatic secretions, as *insoluble phosphate;* it is not capable of absorption, except in very small quantities; the circulation conveys very little, and the tissues, except bones, contain only traces; the bile has rather more. A certain amount of lime must enter the system from the food, and does so mostly as carbonate, which becomes changed and prepared for absorption by contact with alkaline phosphates and gastric acids, but *artificial phosphates* are eliminated almost entirely unchanged, only some of the acid being absorbed. Hence they conclude that the *addition* of such compounds to the food is rather an *obstacle to nutrition*, and that even the soluble acid preparations (lacto-phosphates, etc.) act only as acid principles, and pass out of the system as phosphates of another base. The lime phosphate contained in urine and phosphatic calculi, even when primary, is said to be almost entirely formed within the bladder. These views, as they are not quite in accordance with commonly received clinical

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evidence, seem to require confirmation, but they suggest *moderate* expectation of cure by lime salts.

The bicarbonate, as occurring in carrara water, is soluble by virtue of the excess of carbonic acid, and readily absorbed. *The neutral carbonate*, in small doses (5 or 6 gr.), is soluble in the gastric juice, and is absorbed as a *chloride*. The *chloride* itself, in similar doses, and diluted sufficiently to disguise its caustic taste (as with 3 oz. of sugared water), becomes absorbed without gastric disturbance; but larger doses are apt to cause a sense of oppression, with nausea and diarrhœa. Unduly large doses of lime-water, or of phosphates or carbonates, may also cause gastro-intestinal irritation.

Of that which is absorbed, an equivalent quantity is eliminated, except during the period of growth, and especially of bone-development. There seems to be a power of laying-by some of the substance for this purpose, for, *e.g.*, during the early months of pregnancy, bony growths (osteophytes) sometimes form in the bone of the parent, which diminish with the growth of the fœtus. The eliminated portion is found in the urine, as acid phosphate, and in many other secretions, such as the pancreatic juice, and the semen; some may be detected also in plastic exudations; sometimes it forms calculi. It is often deposited in tumours, fatty, fibrous, and sarcomatous, and in old inflammatory exudations, as in tubercle of lung and strumous glands. About 45 gr. are daily eliminated by an adult man (Husemann).

PHYSIOLOGICAL ACTION. — *External.* — Lime unslaked, or "quick," decomposes and destroys organic matter, and is used sometimes as a caustic, more often as a disinfectant, *e.g.*, in dissecting rooms and in grave-yards; its affinity for water, and its ready combination with sulphur (as in sulphuretted hydrogen), will explain its good effects. It is used by tanners to remove the hair from hides, and by farmers as a fertilizing agent. Its action upon the living skin is irritant and to some extent caustic, but, as it has less "diffusion power," is more superficial and more limited than that of the alkalies proper,—potash and soda. On the mucous membranes, however, its effects may be very severe, as when by accident it enters the eye, or when too strong

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a solution of it, or of its haloid salts, is taken into the mouth. Local inflammation and ulceration may follow, and even a fatal result be produced when the stomach is affected.

Weak solutions or the neutral salts, carbonate and phosphate, in powder, have a local astringent and sedative effect. The "lime-water" of the Pharmacopœia is not strong enough to be *caustic*, but controls secretion, especially from mucous membranes, and renders any tissues pale and dry.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Lime-water and lime carbonates, when taken internally in moderate doses, produce similar local astringent and sedative effects, and act also as absorbents and antacids. The phosphate is a mechanical astringent to some extent, but the sulphate may alternately confine and relax the bowels, according to the irritation produced.

Circulatory System.—No effect upon this system is commonly traced to lime compounds, but full doses of the chloride are said to produce sometimes the symptoms of a "muscular poison," like potash, with lowering of temperature, slowing of pulse, and arrest of heart-action (Rabuteau and others, Comptes Rendues, Feb. 10th, 1873).

Nutrition.—The most interesting point in the physiological action of lime salts is their influence on nutrition, the necessity of phosphate for healthy growth, whether vegetable or animal, being especially evident. Experiments with plants have shown that the phosphates are in close relation with the nitrogenous elements. If, for instance, the nitrogenous husk or coating of a seed be removed, the phosphates are removed with it, and in the starchy part of the grain none are found. In the leaves they occur in the parenchyma, not in the nervules, and generally are most abundant in the cellular parts of vegetables wherein nutrition and reproduction are most active (Liebig). Wheat, planted in earth containing phosphates, germinates and thrives, but if all phosphate of lime be removed, it germinates, indeed, but soon dies. Peas (which contain a larger proportion of azotized matter), when similarly treated, germinate and even bear a crop, but if this crop be sown in a soil without phosphates, it does not flower (Georges Ville, Conférences, Paris,

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1865, Rabuteau). That the improvement in nutrition is not due to the presence or absence of *phosphorus* as such, but to phosphate of lime, is shown by experiments on birds. Wheat contains a large quantity of *phosphate of potash*, and when pigeons are fed upon this alone, and are prevented from getting any carbonate or other salts of *lime*, they waste away, and their bones become weak and brittle. If, on the other hand, they can obtain lime in any form, it becomes changed into a chloride during digestion, and combining with the alkaline phosphates of wheat, provides them with lime phosphates, and secures or favours their due nutrition (Chossat).

There is also evidence that lime phosphates serve especially to nourish cartilage, bone, tendon, and muscle, so that they have been fairly called "restorative or analeptic tonics" to the *locomotor* organs, as iron is to the blood, or phosphorus to the nerve-tissue. Thus, as the result of observations on the reproduction of the shell in crabs, Schmidt found that a combination of phosphate of lime and albuminous material was most favourable for the formation of osteoid cells; phosphate was required for the first growth, though carbonate was formed later. Mr. Bridgman noted the formation of "artificial cartilage" by the passage of an electrical current through a viscous solution of carbonate of lime (Hughes Bennett, Lancet, i., 1863, p. 5). Beneke found that phosphate of lime was specially abundant in plastic exudations and wherever new growth was going on, and he adopted the microscope as a ready means of its detection—for if a drop of sulphuric acid be added to the liquid, crystals of lime sulphate are very quickly formed (Lancet, i., 1851, p. 432). The organism can assimilate phosphate of lime either in the soluble acid form (for the liquids and soft tissues), or to some extent in the basic insoluble form (for the skeleton); but its effects are produced slowly, and without the evident stimulation which we associate with the action of wine, iron, or quinine, so that we describe such lime compounds rather as restoratives than as general tonics, and as *modifying* rather than *stimulating* nutrition. (As a readily noticed, though slight evidence, of the effect of lime phosphates on nutrition, Rabuteau notes that white spots on the nails often disappear under their use).

Besides their effect on ossification, etc., M. Mouriès, a dis-

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tinguished chemist, has described a special effect of lime salts upon "irritability," or vital organic changes, so that if these salts are *absent*, assimilation and nutrition do not go on, and emaciation and death ensue, whilst if they are simply *deficient*, various degrees of lymphatic and osseous disease are produced. He has calculated especially that the food of those who live in towns is deficient in these principles, and that whilst every one ought to have at least 90 gr. daily, many, women especially, receive only about half that quantity; hence a secretion of poor milk and consequent weakly children, and he claims that by the use of a certain food containing lime phosphate with albumen, the proportion of still-born and of rachitic children in many families has been markedly reduced (quoted by Trousseau).

Any difference in the amount of urea and carbonic acid excreted under the influence of phosphate of lime is not exactly ascertained. The chloride of calcium is said to increase the amount of urine (Giacomini); and it is probable that like other chlorides it increases the excretion of urea (Rabuteau).

Lime in Potable Waters.—Waters that do not contain lime are flat and insipid, whilst a proportion of from 7 to even 20 gr. of carbonate in the gallon is compatible with their being good, wholesome, and pleasant (Parkes); such waters may be rendered sufficiently "soft" by boiling. Hardness dependent upon a soluble bicarbonate of lime is best treated by Clark's process, of adding slaked lime, which precipitates an insoluble carbonate.

Lime sulphate is contained in water from selenitic rocks, and a proportion of from 6 to 21 gr. per gallon must be considered unwholesome; it is liable to irritate the bowels, causing alternately diarrhœa and constipation, as was verified, especially in some prisons and hospitals of Paris, by Parent Duchatelet; such water is not much softened by boiling.

Nitrate of lime is sometimes found in drinking water, being derived probably from organic sources; it is likely to cause diarrhœa.

Water from *magnesian limestone*, containing magnesia with some carbonate, and 4 to 12 gr. per gallon of *sulphate* of lime,

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has been considered specially likely to cause *goître;* but professional opinion, though still divided on this question, is now more inclined to the negative view.

Dr. McClelland (in an able report on the medical topography of Bengal) certainly gave remarkable instances from many villages scattered over a large district where the inhabitants, though living close together, were affected with goître or not, according as to whether they drank or not of certain wells, to which they were restricted according to caste; and he found that the wells used by goîtrous persons contained up to 25 per cent. *carbonate* of lime (Abstract in Brit. and For. Rev., 1861, i., p. 42, and Watson's Practice of Physic, vol. i., 3rd ed.); the presence of magnesia is not mentioned. Dr. Inglis, in his treatise on the subject, Dr. Coindet, of Geneva, and other authorities, have agreed in blaming lime-waters mainly for the production of goître, and its greater prevalence along ranges of lime-rock, as in Nottinghamshire, Derbyshire, and in parts of South America, are quoted in favour of the same view. Some connection has been further traced between this cause and *cretinism*, as well as goître; and Kolliker and others maintain, not without the support of post-mortem evidence, that by the habitual use of such lime compounds ossification is increased at *the base of the skull*, so that the cranial foramina become narrowed, and the supply of blood to the brain lessened (Brit. and For. Rev., Jan., 1861, p. 46). On the other hand, Dr. Mitchell has published a careful report upon the "Nithsdale neck," prevalent in that part of the south of Scotland, and has shown that some other element than water must be concerned. It is true that many of the wells used contained from 4 to 14 gr. of carbonate in the gallon (with magnesia), but that limit is compatible with health, and several wells in the same district contained the same quantity, and even to 24 gr., without the production of any goître (Brit. and For. Rev., April, 1862).

SYNERGISTS.—Alkaline and earthy bases have a similar absorbent action to that of the *carbonate of lime*, and re-constituents generally, such as iron and cod-liver oil, are adjuvants to the lime phosphates; aromatics also are often well combined.

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ANTAGONISTS AND INCOMPATIBLES.—Mineral acids, laxatives, and irritants either decompose or neutralize the action of lime compounds, with the exception of *phosphoric acid*, which is sometimes used with the acid phosphate, to render it more soluble.

Saccharated lime is said to be a specially good antidote to *carbolic acid*, and the following is Ferraud's formula:—℞. Sugar 15 parts, water 40 parts; dissolve, and mix thoroughly with quick-lime 5 parts (Lancet, i., 1876).

Hypochlorite of lime is an antidote for sulphuretted hydrogen.

THERAPEUTICAL ACTION.—*External.*—Epithelioma.—A mixture of quick-lime (2 parts) and caustic potash (1 part) is sometimes a useful escharotic for superficial forms of epithelial cancer; it should be mixed, just before using, with sufficient alcohol to form a paste ("Vienna paste"), and spread over a suitable aperture in diachylon plaster previously placed on the part; its action begins immediately, and lasts for about half an hour; the eschar is dark-coloured, and separates in from ten to twelve days. A proportion of 6 parts of lime to 5 of potash is recommended by some authors, and for application to deeper-seated parts, such as the neck of the uterus, a combination of 1 part of lime with 2 of potash is used, especially by French surgeons ("caustique Filhos"); it is fused by heat, and poured into a small mould of lead, which can be cut away as the caustic is required.

Chronic Tonsillitis.—A mixture of equal parts of lime and caustic soda has been recommended under the name of "London paste" for occasional application to chronic conditions of enlarged tonsil (Mackenzie), but has not come into general use.

Onychia.—Prof. Vanzetti has recommended the application of caustic lime in preference to nitrate of lead for onychia maligna, and has reported two successful cases, in one of which the application was renewed several times, and in the other it was left in continuous contact (Practitioner, vol. xiii.).

As a Depilatory to remove superfluous hair, lime is sometimes used with arsenic (as in the Turkish "Rusma"), or in the form of a hydrated sulphide, prepared by passing hydrogen through a mixture containing 2 parts of lime with 3 parts of

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water: when saturated with the gas, this forms a greenish jelly, which is spread upon the part for a few minutes, and then removed with an ivory knife (Trousseau).

As a **Moxa**, or to produce an issue, a fragment of lime may be slaked on the skin by adding to it a few drops of water; much heat is produced, and the neighbouring skin requires to be protected.

As a **Vapour Bath**, a piece of unslaked lime half the size of a man's closed hand is wrapped in a moist cloth, and this again in a dry one doubled several times, and fastened securely: and if one of these packets be placed on either side of a patient whilst in bed, the moist heat soon induces a copious perspiration lasting for one or two hours (Serre d'Alais, Bull. de Thérap., 1846). Dr. Hassall has recommended this as a ready means of establishing reaction in cholera, and others have used it in tetanus.

Hay-Fever.—In this malady the vapour evolved from lime chloride has been found serviceable, when the air of the patient's house is impregnated with it as far as possible; the solution should be used as a wash to the face and hands. It is reasonably presumed to act by destroying a fermentative or "germ" source of irritation to the mucous membranes (Elliotson).

Croup and Diphtheria.—In the form of a warm, finely-atomized spray, solutions of lime (1 in 30), have been much commended as chemical solvents of croupous membrane. Förster, Biermer, and others have shown that such membranes, and especially their fibrinous constituents, are soluble in lime-water (Archiv der Heilkunde, v., p. 522), but doubts have been expressed whether such an effect can be usefully and practically obtained in the living body. Biermer treated a true case of membranous croup (verified by rejection of membrane) by means of a warm lime-spray, and although the patient was in great peril, he obtained relief and finally recovered;—this physician, however, generally gave calomel at the same time (Brit. and For. Rev., July, 1865). Kuchenmeister has recorded several good cases treated successfully by the spray (Bull. Gén., April, 1865), and the experience of Steiner proved that diphtheritic layers on the fauces were

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dissolved by it in a marked manner: subsequently, however, the growths formed again, and could not be controlled by the remedy (Jahrb. für Kinderheilk., 1870). Beigel has reported good results with it in croup, and Geiger, of Philadelphia, in diphtheria (Practitioner, i., p. 101); but Senator has more recently written against its employment, even from a theoretical point of view, and doubts its power of dissolving membranes "in situ." Gottstein and others consider the direct application of lime-water to the larynx by means of a brush to be more advantageous than the spray, and Albers, of Berlin, in desperate cases has injected the solution into the larynx from below, passing his syringe between the tracheal rings: cough was caused, and shreds of membrane were ejected (Berlin. Klin. Woch., Feb. 1, 1869, Ranking, i., 1870). The experience of the profession is not yet such as to enable us to decide the real value of lime-water applied locally in the treatment of these affections, but my own results have not been largely in its favour. Mackenzie finds it useful "when the false membrane is not very thick" (On Diphtheria, p. 69).

Lactic acid and carbonate of lithia act similarly, and even better, in dissolving croupous membranes; Kuchenmeister, however, still maintains the superiority of lime-water. Sanné recommends the saccharate.

Cancrum Oris—Ulcerations.—Applied in substance or in solution, the chloride of lime is a valuable antiseptic and stimulant to fœtid discharging surfaces. In cancrum oris, a little of the dry powder may be applied by the finger, and washed away immediately afterwards, and in unhealthy ulcerations about the gums in general, and in salivation, a wash may be used containing 2 dr. to the pint of water, with glycerine, or ordinary lime-water may be used with nearly equal benefit.

A proportion of 1 to 10 or 15 of water has been found extremely useful, applied as a compress in cases of ruptured perineum, when the torn surface is apt to discharge offensively, and in unhealthy and indolent ulcerations of any part, the same remedy, or even ordinary lime-water, will diminish discharge, cleanse the surface, and promote a healthy action. Chloride of lime lotions are also good in erysipelas.

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Skin-Diseases.—In pustular and erythematous skin-diseases, preparations of lime are often very useful. In *chronic acne*, I have often ordered lime-water, mixed with an equal part of rose-water, and applied three or four times daily with the best results. In *ecthyma*, it is commended by Mr. Wilson, and in the discharging stages of *eczema* and *impetigo*, it makes a useful lotion. In impetigo capitis, and in fissured nipples, lime-water mixed with oil is good. In chronic eczematous and scrofulous disease, lime salts are often useful when given *internally* (Tilbury Fox speaks well of "saccharated wheat phosphate" in such conditions). Cazenave thought the chloride good in lupus. In *carbuncles* and *boils*, a compress soaked in lime-water and covered with oiled silk, often acts beneficially; it checks inflammation, soothes pain, and promotes suppuration more quickly than ordinary poultices. In *erythema* and the *pruritus* of reddened and irritable skin, lime-water has a sedative, moderately constringing effect, and may be used either alone, or as a vehicle for other similar remedies. In *pruritus pudendi* it is often useful when applied freely and tepid, and in *osmidrosis* it will relieve the unpleasant secretion from the sweat-glands. Dusting powders containing precipitated carbonate of lime are used for *erysipelas* and *erythema*, and in cases of much sebaceous secretion, especially about the face. Combined with lard as "chalk-ointment" it is often a good application for indolent and irritable sores. In *tinea capitis*, after thorough cleansing, lime-water may be brushed in, but as a rule stronger remedies are necessary: a lotion of chloride is more satisfactory. In *scabies*, a strength of 1 oz. of chloride to 1 pint of water has been found sufficient to cure, but a more dependable preparation is made by boiling together 1 part of quick-lime and 2 of sulphur with 10 of water; this should be constantly stirred till well mixed, and then the liquid poured off for use; it is too strong to be rubbed in like sulphur ointment, but should be applied lightly with a brush, and afterwards removed with a warm sponge, if necessary (Lancet, i., 1865). Pharmaceutists now commonly make such a preparation under the name of liquor calcis c. sulphure (*v.* p. 43).

Burns and Scalds.—Lime-water, mixed with an equal part of linseed- (Carron-) oil, or better, of olive-oil, was long since

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commended by Boyle and by Velpeau as a suitable dressing for the early stages of burns in every degree, and, though rather unpleasant, it has come into general use. It may be applied on carded cotton, and if the skin be unbroken, resolution of inflammation is promoted by it, and if suppuration occur, the liniment controls it, and hastens cicatrization. It relieves pain and inflammation in cases of wasp and other stings (Dauverne).

In severe cases of **Small-pox**, Dr. Joseph Bell recommended the same liniment to be applied to the face on cotton wool, carefully arranged to cover the affected part, but leaving apertures for the eyes, nose, and mouth. The wool should be fastened with another covering or with tape, so as to prevent admission of air, and by this means pitting may be prevented or decidedly lessened. An improved formula is a saturated sucrate of lime, made with lime, sugar, water, and glycerine; it forms a cool, drying varnish, and for burns may be diluted with oil, or ether may be added (Pharm. Journ., Oct., 1873).

Chronic Discharges.—In chronic mucous and purulent discharges, lotions and injections of lime-water exert a most beneficial influence, as may be observed in chronic urethritis and in leucorrhœa, syphilitic or otherwise; in the former, a combination with mercurial oxides, such as the "black or yellow wash," is still more potent, and is in daily use for all forms of syphilitic ulceration.

The profuse nasal discharge, so usual in scarlatina and also muco-purulent otorrhœa, may be well and safely treated by washing out the affected parts with a tepid injection of milk and lime-water three or four times daily: over the affected ear a compress of lime-water, worn at night, is often advantageous. In chronic purulent ophthalmia a lotion containing chloride of lime is effective.

Ascarides.—Rectal injection of a few ounces of lime-water several times repeated, is effectual in curing ascarides, and Dr. Price, of Margate, and Kuchenmeister have reported some successful instances of this treatment (Lancet, i., 1864); it has long been a favourite prescription of mine.

THERAPEUTICAL ACTION.—*Internal.*—Lime-water was formerly much esteemed as an internal medicine, and was

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given not only as an antacid and astringent, but also as an antiseptic, and especially as a lithontriptic or solvent of calculi. It was not unfrequently given in excess, and produced irritant effects, but its use now is more restricted, and the doses given are smaller and more diluted.

Dyspepsia—Vomiting.—When digestion is accompanied with discomfort and oppression, or with acidity, pyrosis, and flatulence, especially if there be a tendency to diarrhœa, and to acidity of urine, lime-water and the carbonate of lime are often more serviceable than alkalies, because they are not only antacid but astringent. I have found them specially useful in the dyspepsia of chlorotic women, marked by the above symptoms, and generally by craving for acids and dislike to animal food. When flatulent distension affects the lower bowel, lime-water has been used in enema as absorbent of carbonic and other gases. Dr. Habershon has recommended the carbolate of lime in such conditions (Lancet, i., 1868). For cases of acid dyspepsia, when flatulent distension is not so prominent a symptom, but when there are heartburn and pain with evidence of gastric congestion, the bicarbonate of lime, dissolved with an excess of carbonic acid in the slightly effervescent form known as carrara water, is very useful, for it is less nauseous to some patients, and more easily tolerated than lime-water, so that more of it may be given at a time; it may be mixed with an *equal* part of milk, whilst of lime-water not more than *one-eighth* part should be used.

For the special symptom of nausea and vomiting from irritative gastric conditions, milk and lime-water is a simple and often effective treatment; given frequently in small quantities, iced, it provides digestible nourishment which is sometimes better retained than any other. It is valuable in the vomiting of pregnancy, and even in that of gastric ulcer, in which latter malady, only a dessertspoonful in a wineglassful of milk should be tried at a time. The lime acts partly as a sedative to the mucous membranes, partly as an antacid, and partly mechanically by breaking up the curd of milk; hence it is particularly useful as an addition to cow's milk for children brought up by hand, only in any case where constipation is marked, soda-water may be substituted for a time.

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Mr. Metcalfe Johnson has written highly of the value of hydrated *phosphate* of lime in the sickness of pregnancy; and Dr. Leared of the chloride (½ dr. to 1 dr. liq. calcis chloridi) in sarcinous vomiting. Dr. Cleland specially recommends the saccharate as a better antacid than magnesia, and useful in dyspepsia dependent on either too little or too great secretion of gastric juice; it does not constipate like other lime compounds; it may, however, cause nausea if taken on an empty stomach (Edin. Med. Journ., 1859).

Carrara water is suitable for taking with wine at the later meals, and several other natural mineral waters containing lime are of acknowledged value in gouty and acid forms of dyspepsia generally (*v.* p. 222): Seltzer contains 3 gr. of carbonate in the pint, Pyrmont 4, Kreuzbrunnen 4·13 with much carbonic acid, Wildungen 5·4 to 9·7, and Pouges (a Spa between Paris and Lyons) contains as much as 12 gr., and is of great repute. Dr. Basham found such waters especially suitable for hypochondriacal, but not for anæmic cases.

Intestinal Catarrh—Diarrhœa.—Lime-water and lime carbonate are useful in these conditions, especially if gastro-intestinal acidity be present, as it usually is in young children; the breath is then offensive, the motions frequent, loose, greenish, sour-smelling, and deficient in bile; the abdomen is distended, cramping pain occurs at intervals with drawing-up of legs, and there is often sickness. Restriction to milk and broth diet, with the addition of 1 or 2-gr. doses of carbonate of lime will often cure this disorder; in the diarrhœa of dentition as well as in the more chronic forms connected with strumous or mesenteric disease, such treatment is specially indicated. (Castor oil may be required at first to remove any cause of direct irritation such as undigested food, mucus, etc., and the use of insoluble lime salts should not be prolonged more than necessary, otherwise irritation, or some degree of obstruction may be caused.)

In *chronic diarrhœa* dependent upon relaxed condition of the alimentary canal, and also when kept up by ulceration of the bowel, I have used lime preparations with the best possible effect. Bretonneau recommended them in enema for these cases.

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In the *diarrhœa of enteric fever*, and of *tuberculosis*, milk and lime-water may prove of great, if only temporary service, but should not be used in large quantity if hæmorrhage or symptoms of acute inflammation be present. The alkaline earth is plausibly supposed to combine with the secretions of the ulcerations and to form a layer which protects the terminations of sensitive nerves against contact with the contents of the bowels. Mialhe especially applied this explanation to the phosphate of lime, which salt has been much used in the treatment of diarrhœa and of acidity, and owing partly to its phosphoric element, is considered to exert a special restorative power: according to him, if given with bread and sugar it becomes changed by the slight acid of the former and by the gastric acids into a soluble acid salt, which does not itself coagulate albuminoid material, but when brought into contact with a small proportion of alkali, becomes converted into an insoluble basic phosphate of gelatinous character, which protects the mucous membrane, and checks diarrhœa.

This salt was the principal ingredient in the "white decoction" of Sydenham. The quinovate of lime is specially commended by Kerner (*v.* Vegetable Kingdom).

Aphthous Conditions of the mouth and alimentary tract, when occurring in infants, with green but not necessarily liquid stools, may often be cured by lime-water or prepared chalk.

Bone-Disease—Fractures.—Piorry furnishes evidence of the value of phosphates in osteo-malacia, or softening of the bones generally, also in spinal caries or "Pott's disease" (Gaz. des Hôp., 1856), and I have certainly seen them very beneficial in cases of caries and joint-disease. Reasoning from the observation that birds with a broken limb lay eggs without shell during the process of repair, Dr. Fletcher was led to administer a mixture of calcined bone, prepared chalk, and lime-water in cases of fracture (in man), and reported several cases of very early union of long bones (Lancet, 1846). Milne Edwards made similar observations on dogs and rabbits, producing fractures as nearly as possible alike, and then finding that the animals who got lime phosphate recovered more rapidly than the others; and M. Gosselin found the same results in men

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(Comptes Rendues, xiii., p. 631, and Brit. and For. Rev., July, 1856): on the other hand, it has been pointed out that in fractures of old persons, in whom the bones are brittle, lime salts are better avoided. They have been strongly recommended during pregnancy and lactation in enfeebled mothers, both to relieve their neuralgia, debility, and dyspepsia, and also to favour the development of healthy non-rachitic children (Der Prakt. Arzt., May, 1869); and I have for years recommended their use in backward dentition, delayed power of walking, and retarded closure of the fontanelles. These are usual signs of a rachitic tendency, and in the fully-developed malady of rachitis, saccharated lime is strongly to be recommended. It is true that although parts of the bones become softened in this disease, and are deficient in lime, often at the same time, lime phosphates are largely excreted in the urine, so that the fault is one rather of mal-assimilation than of actual deficiency, yet I agree with Dr. Ringer that the administration of lime, and especially of lime-phosphate, "appears to control this defective and perverse nutrition, and to induce healthy growth, so as to favour consolidation of the skeleton and improve the condition of soft parts," and that practically they are extremely valuable, though not always alone curative. He compares this use of it to that of iron in anæmia, where the fault is equally one of want of assimilation rather than of quantity. As already mentioned under the physiological action of lime (*v.* p. 512), it has been objected that it is so little soluble that quite sufficient may be introduced with ordinary food, and that to give it in medicine rather interferes than otherwise with normal nutrition (Paquelin and Jolly); but practically we do not find it so. Considering, however, the evident insolubility of ordinary tribasic phosphate, M. Dusart and others have introduced acid solutions—lacto-phosphates—which have come much into vogue, and are sometimes very suitable, but it must be remembered that often in unhealthy rachitic children most of the secretions are already too acid, and need rather to be neutralized by a basic earthy salt, and any excess of acid would tend rather to dissolve osseous salts, and cause them to be eliminated, not deposited. It may often be better to give the ordinary salt (phosphate) recently prepared, if possible, and with flour or milk,

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and to trust the stomach to absorb what is needed, and the surplus will pass through the intestine, not injuriously. The combination of lime phosphate with sodium chloride (calcaria phosphorica salita) has been found very soluble (Sabellin, Dorogow, Husemann, p. 724). The *sulpho-carbolates* of lime have been specially recommended in rickets, but Dr. C. Ritchie did not find them serviceable (Med. Times, i., 1871).

There is reason to think that natural salts of lime, such as have recently passed through *organic* structures, are preferable to such as have been deposited as *mineral*. Thus, Piorry recommended, in bone-softening and spinal curvature, fine filings of fresh bone, 1 oz., to be taken in milk or rice-milk, and found it succeed when proper light, warmth, and food had failed (Gaz. des Hôp., 1856, No. 139, Med. Times, i., 1857).

Others have derived medicinal phosphates from the *vegetable* kingdom. Thus Dr. Hake and Dr. Tilbury Fox recommend a strong decoction of good bran to be made and evaporated, and the residue mixed with sugar; and a preparation of this kind known as "saccharated wheat phosphates" has come largely into use for mal-nutrition, rickets, etc. (Med. Times, i., 1866). It may be desirable to state again that the advantage of lime salts in bone-disease is not traced simply to chemical and physical processes, but also to direct improvement of digestion, absorption, and nutrition.

Struma—Glandular Disease.—Lime-water was long since commended for the treatment of suppurating glands, and of ulcerations, as well internally as locally (Shapter, Pereira). The phosphate was especially found serviceable, though not always curative, in the different manifestations of scrofula, by Beneke (Lancet, 1851), and by Stone (New Orleans Med. Journ., and Bull. Gén., 1852, t. xlii., p. 229); whilst Beddoes, Fourcroy, A. T. Thomson, and more lately Dr. W. Begbie, have reported very good results from the chloride. Dr. Beddoes collected upwards of 100 cases, including many of so-called "tabes mesenterica," and Dr. Begbie has corroborated the good results to be obtained from doses of 10 to 20 gr. daily. He records also good cases of the subsidence of enlarged parotid and lymphatic glands under the same medicine, when iodine and cod-liver oil had failed to cure (Edin. Med. Journ., July, 1872). It must be

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stated, however, that in the experience of most other observers, these latter remedies have superseded lime salts, and that Mr. Benjamin Phillips and other writers on scrofula have expressed themselves much less favourably concerning them.

Of late years, a mineral water in the West Indies has obtained great repute in the treatment of glandular enlargements, and has been found to contain calcium chloride, though in small proportion. The "Bridge of Allan" waters contain it, and have a purgative effect in consequence. I have myself given the chloride a fair trial in 1 to 5-gr. doses twice daily for lymphatic disease in children, and have sometimes seen good results from it when persevered with; though, as a rule, I prefer the carbonate to other lime compounds.

The use of sulphide of calcium in strumous and scrofulous sores and enlarged glands, and in localized suppurations of any kind, will be found fully discussed under sulphur.

Anæmia.—In anæmia and debility, the consequence of overwork, of close confinement, etc., Dr. Ringer speaks highly of the phosphate of lime, especially when combined with the carbonate and with iron.

Chorea.—Rodolfi has recorded cases of chorea treated by lime chloride, 7 to 15 gr. in twenty-four hours, and finds it suitable for all cases provided that there is no "cerebral hyperæmia;" improvement began at once, and cure resulted in about sixteen days (Med. Times, i., 1869). Aperients were also given, and, as Jaccoud remarks, belladonna was combined with the lime, so the results must be held doubtful.

In nerve-disorder with sleeplessness, and in infantile convulsion, Dr. Hammond has found the *bromide* of calcium more readily taken, and more effective than that of potassium, and I can to some extent verify his observations.

Phthisis—Chronic Bronchitis.—In the early stages of phthisical anæmia and debility, especially in excitable florid persons with tendency to headache and dyspepsia, also when in later stages profuse sweating, or expectoration, or diarrhœa is present, or when the menses are frequent or profuse, the carbonate or phosphates of lime often exert a good influence in lessening such discharges and in improving strength; even when actual softening has occurred and cavities formed, I have

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given these salts with the object of assisting cretaceous degeneration, and often with benefit. Lime well supplements cod-liver oil, and the two remedies may be suitably combined, since they form an emulsion readily taken by children—1½ parts of lime water to 1 of cod-oil is perhaps the best proportion (Med. Times, i., 1862, p. 399). Van den Corput, a Belgian physician, though praising this combination, recommends rather the chloride flavoured with anise or such proportions of lime-water, etc., as will make a solid jelly ("jecoro-calcaire savon"), which is still better taken (Med. Times, ii., 1870, p. 624); it has not, however, come much into use in this country. Cod-liver oil does not mix well with syrup of lacto-phosphates, and is liable to become rancid when in contact with it. At a hospital in Moscow excellent results were obtained in the treatment of phthisis by freshly-calcined bone.

The hypophosphites of lime were introduced as the best compound for the treatment of phthisis, owing their value in part to the base, and in part to the hypophosphorous acid contained. The rather extravagant praise which was bestowed upon them has not been supported by the majority of the profession, and opinions are still divided as to their real powers. I believe myself that they are sometimes of much service. Rabuteau remarks that as hypophosphites raise animal temperature, the phosphates would seem more rational remedies for phthisis; that dogs never have phthisis (?), probably because they eat so much bone; also that phosphates are commonly in excess in the urine of the phthisical, and therefore to supply them artificially is reasonable. Charters has lately published illustrations of their value in night-sweats (Lancet, i., 1876), and Gugot has made a similar observation (Husemann). Mr. Pidduck specially praises the iodide of calcium in struma and phthisis; it is tasteless, non-irritant, readily decomposed, but not readily producing iodism (Med. Times, i., 1858). Dr. Sawyer states that he has seen, in chronic phthisis, better results from calcium chloride than from other medicines, hypophosphites of lime and soda included. He recommends 10 gr. of the chloride with 1 dr. of water and of glycerine, to be taken in milk after meals, and finds this often "check night-sweats, increase weight, and dry up pulmonary lesion" (B. M. J., i., 1880).

In *chronic bronchitis*, I have frequently seen lime-water, and

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also carbonate of lime, act well in diminishing profuse expectoration and troublesome cough; it should be given internally, and the lime-water applied locally by an atomizer.

In *Gangrene of the Lung*, Dr. Graves advised the chloride with opium.

Cancer.—Besides the local application of lime-water and lime chlorides to cancerous sores, a power has been claimed for these remedies taken internally to diminish malignant growths; thus, a curious case, in which an extensive mammary cancer separated and fell off after a prolonged use of lime carbonate, is recorded by Dr. Peter Hood (Lancet, ii., 1867, p. 454); the patient was advanced in years, and for a long time took the carbonate, as prepared from the inner side of oyster shells, 10 to 20 gr. twice daily. Another case, cured under the same remedy, is also mentioned.

(If the taking of lime salts have any power in inducing the cretification of tubercle—and there is some clinical evidence to that effect—and if they can diminish the blood-supply of a fibroid tumour and hasten cretaceous degeneration of it, as suggested by Mr. Spencer Wells, then it is not unreasonable to expect advantage from them in some cases of cancerous degeneration, but I am not aware of other evidence in this direction.)

Uterine Disorder—Menorrhagia—Fibroid Tumour.—There is a general consensus of opinion as to the power of lime salts to relieve uterine hæmorrhage. Dr. Rigby published a marked case dependent on "fibrous tumour" (Med. Times, ii., 1854) treated by the chloride, and Dr. Rogers, Dr. Routh, and others have recorded similar experience; doses of 10 drops of the liquor calcis chloridi, increasing by degrees to 30 or 40 drops, and continued for some months, are recommended (Ranking, 1871, Lancet, 1873). In too early and too profuse menstruation, I have been accustomed for many years to prescribe the carbonate of lime with much success. Mr. Spencer Wells believes that the chloride acts by leading to atheroma of vessels, and hence is useful in lessening the growth of uterine fibroids, and may even cause their disappearance (B. M. J., i., 1868). Certainly, in some instances under my care, uterine and other tumours have diminished under treatment by carbonate and chloride of lime.

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It is true, as remarked by Dr. Meadows, that large quantities have been given to many patients with uterine fibroid tumour without any result, and he ridicules the idea of any possible promotion of calcification by such means (Lancet, ii., 1873, p. 3): he argues that a natural process of atrophy may occur, and that calcareous degeneration is only a consequence, not a cause of this. Dr. Meadows ridicules equally the idea of lime curing rachitis: but no reasoning from probabilities should prevent our appreciating clinical facts.

Uric Acid Deposits—Calculus.—In these maladies, lime has by no means retained the reputation it formerly held, but may certainly give some relief. The secret remedy of a Mrs. Stephens received so much commendation, that Parliament purchased the recipe for £5,000 about one hundred years ago, and it was found to be mainly of calcined egg-shells (lime carbonate) and soap, with vegetable bitters, and though much of the benefit must be set down to the alkali of the soap, yet Whytt obtained very good results afterwards from simple lime-water. Lime salts may relieve vesical pain and inflammation, and by a constringing and sedative effect on the mucous membrane of the bladder may lessen the ropy discharge and the general sensibility; a solvent action may also be exerted, but not probably to a great degree; the benzoate of lime has been credited with more decided effect. Lime-water should also be injected, after washing out the viscus with soothing mucilaginous liquids. Professor Stillé remarks, "There is reason to believe that uric acid gravel may be dissolved and eliminated under the use of lime compounds. How far they are superior to the carbonates of the alkalies for this purpose will depend chiefly on the state of the digestive organs—when these are feeble, lime-water is the better preparation."

The waters of Wildungen, which are much used in lithiasis, owe their efficacy principally to lime carbonate (*v.* p. 222).

Diabetes Mellitus.—Kissel reports two cases cured by lime-water, improvement being for several weeks very slow, but afterwards rapid and marked. My own experience, however, has convinced me that this is inferior to many other remedies.

Albuminuria.—On account of the power of lime salts to dissolve organic membranes, they have been recommended in

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chronic Bright's disease, and in post-scarlatinal albuminuria "to dissolve proteinous infiltrations of the kidney." Kuchenmeister reports cases treated by large doses of lime-water and soluble lime salts, with immediate and marked increase in the quantity of urine passed, and with corresponding subsidence of the dropsy. The amount of albumen was lessened, but sometimes slight hæmorrhage occurred (Ranking, 1869, Rev. Méd., Feb., 1870). His results have not been widely corroborated, but Baudon reports a case in which the iodide of calcium seemed to succeed after iodide of potassium failed; quinine and iron were given also (Practitioner, i., 1869).

From our knowledge of the styptic properties of lime salts, we should rather expect them to restrain renal hæmorrhage than to cause it, and Stromeyer and Caspari report the value of the phosphate for this purpose.

PREPARATIONS AND DOSE.—*Liquor calcis:* dose, ½ to 2 fl. oz. or more (contains ½ gr. to the ounce). *Liquor calcis saccharatus:* dose, 15 min. to 1 fl. dr. (contains 7·11 gr. to the ounce). *Linimentum calcis* (lime-water and olive oil, equal parts). *Creta preparata:* dose, 10 to 60 gr. *Mistura cretæ:* dose, 1 to 2 fl. oz. (contains chalk ¼ oz., gum-acacia ¼ oz., syrup ½ oz., cinnamon water to 8 oz.). *Pulvis cretæ aromaticus:* dose, 10 to 60 gr. (contains cinnamon, nutmeg, saffron, cloves, chalk, cardamoms, sugar). *Pulvis cretæ aromaticus c. opio:* dose, 10 to 60 gr. (contains 1 gr. of pulv. opii in 40). *Calcii chloridi:* dose, 2 to 10 gr. *Vapor chlori* (made with chlorinated lime). *Calcis phosphas:* dose, 2 to 20 gr. or more. *Calcis hypophosphis:* dose, 2 to 10 gr. Besides these officinal preparations, there are many compounds such as the iodide, the bromide, and the carbolate of calcium of which the lime is the less active ingredient, and of which the properties are mainly those of iodine, bromine, etc. There are also many private preparations of lime, such as the lacto-phosphate, the compound syrup of the phosphates (Parrish), and others. A number of formulæ for lime sucrates, hypophosphites, etc., are given in the Pharm. Journ., June, 1877.

The *sulphide of calcium* is not officinal: convenient granules of it containing $\frac{1}{10}$ gr. and up to 1 gr. are now prepared.

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Various formulæ for "phosphated bread" and natural forms of phosphate have been published. Superphosphate of lime ½ oz., carbonate of iron ½ oz., butter and sugar, of each ¼ lb., flour ¾ lb., treacle ½ lb., make 80 cakes (Med. Times, i., 1859). Acid phosphate of lime and moist carbonate of soda may be used as a good "baking powder" (Horsford, Ranking, ii., 1860). Chevrier has an aerated water containing tribasic phosphate (Pharm. Journ., Sept., 1874). Dannecy recommends to wash and powder beef bones, and boil them for an hour with carbonate of soda and water, then to wash in a filter—to dry and sieve (Bull. de Thérap, March 15th, 1858).

CERIUM, Ce, = 141.

This metal, which is not a common one, was discovered by Berzelius, in a Swedish ore called cerite or heavy-stone—a silicate of iron, calcium, lanthanium, didymium, and cerium, which last is obtained from it in the form of a grey metallic powder: oxalic acid is used in the process, and hence oxalate of cerium is the best-known commercial salt: it is the only one officinal.

CERII OXALAS—OXALATE OF CERIUM, $Ce_23(C_2O_4)9H_2O$, = 708.

PREPARATION.—By mixing a solution of any soluble salt of cerium (*e.g.*, the chloride) with solution of oxalate of ammonia—the oxalate of cerium precipitates.

CHARACTERS AND TESTS.—A white granular powder, which when heated to redness gives a reddish-brown residue of impure oxide, soluble in boiling hydrochloric acid without effervescence. This solution gives, with sulphate of potash, a white double sulphate of potassium and cerium: the oxalate itself is insoluble in water. The soluble salts, such as the chloride and nitrate, have a sweet astringent taste: with alkalies and their carbonates they give yellowish-white precipitates.

PHYSIOLOGICAL ACTION.—*Internal.*—There is some *clinical* evidence in favour of attributing to cerium a sedative

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action upon the gastric mucous membrane and upon the nervous system, and especially on reflex excitability, but I am not aware of any physiological research as to the properties of this drug.

SYNERGISTS.—Bismuth, silver, and cyanides.

THERAPEUTICAL ACTION.—*Internal.*—**Vomiting of Pregnancy, etc.**—Sir J. Simpson introduced the oxalate of cerium "as a sedative tonic resembling bismuth and silver," valuable in irritative dyspepsia and vomiting, especially when dependent on pregnancy (Edin. Month. Journ., Dec., 1854, and Med. Times, i., 1855). Several years later he wrote strongly in favour of its especial and proved value in the last-mentioned condition and in sympathetic uterine vomiting generally. He calls it "the simplest and surest remedy," states that he has cured with it more cases than with any other single medicine, and records several illustrations of its prompt and effective action in obstinate cases which had resisted all ordinary treatment: he gave 1 to 2-gr. doses in pill (Med. Times, ii., 1859). Dr. C. Lee and Dr. W. Curran have recorded similar experience, but the latter rather confused his results by giving bromide and bark at the same time. Dr. C. K. Mills (U.S.) found that the nausea and vomiting of pregnancy almost always yielded promptly to a few doses: of eleven cases reported, ten were relieved permanently, one only for a time. Similar symptoms associated with dysmenorrhœa, flexion, and other uterine disorders, and with hysteria from anxiety, grief, overwork, and the like, were also relieved by cerium. Obstinate vomiting occurring in the course of phthisis, and during typhoid fever, was successfully treated by 2 to 3-gr. doses (Med. Record, March, 1876). The amount of published evidence as to the general use of the drug is meagre, but I have myself often obtained excellent results from it. Dr. Image, in a recent paper, attributes occasional disappointment to the use of too small doses: he recommends 10 gr. with tragacanth, tincture of orange, and water, every four hours, the first dose being taken half an hour before rising. He quotes a case in which vomiting always had commenced in the fourth week of pregnancy and lasted till the eighth month, but with this

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remedy the attacks, though recurring at intervals, were invariably checked in two or three days, and of a great many cases of pregnancy with vomiting, not a single one was unrelieved by the same treatment (Practitioner, June, 1878). He found it also efficacious in nausea from uterine irritation, and I have had similar experience on many occasions. I have not required to use so large a dose, but it should certainly be tried if smaller ones fail. Dr. Busey has lately recommended oxalate of cerium to obviate the nausea and headache produced in some persons by opium, just as Da Costa recommended bromide, and others coffee; it has the advantage of small bulk and of tastelessness (Practitioner, i., 1879, p. 214).

Dyspepsia—Gastrodynia, etc.—Simpson recommended the oxalate in primary as well as in reflex gastric disorder, and Dr. C. Lee has given instances of its value in pyrosis, in phthisical and atonic dyspepsia; it may be used in the class of cases in which bismuth is indicated. Dr. Mills found it act best when morbid sympathetic influences were a main cause of the indigestion, and depressed or deranged innervation of the stomach existed: in diarrhœa from nerve-irritation, cerium was also successful; "it seems to have the power of diminishing reflex excitability of the alimentary tract;" in dysentery, gastric ulcer, cancer, gastro-enteritis, he tried the medicine, but with less satisfactory result (Med. Record, March, 1876).

"Chronic Cough."—Mr. Clark has recorded cases of chronic lung-disorder with some partial consolidation, and accompanied with dyspnœa on exertion and violent *morning cough* producing sickness, the symptoms were much relieved by the (apparently) sedative effect of oxalate of cerium, given in 5-gr. doses half an hour before rising (Practitioner, April, 1878).

Epilepsy.—Dr. Ramskill has recorded two cases of epilepsy preceded by a "gastric aura"—*i.e.*, "a sense of faintness, and of something turning upside down at the epigastrium"—which were benefited by the oxalate of cerium, when belladonna and bromides had failed to relieve. Cases of epilepsy without this aura were not benefited, and Dr. Ramskill suggests that in the gastric cases there was a primary failure of action in the splanchnic nerves, that the medicine acted as a sedative and conservator of their power, and that this influence being con-

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veyed to the medulla lessened its excitability (Med. Times, i., 1862). The cerium salt has at least this advantage over nitrate of silver, that it will not darken the skin.

PREPARATION AND DOSE.—*Cerii oxalas:* dose, 1 to 5 gr. or more—according to Dr. Image, 10 gr. For an infant or child under two years, ¼ to ½ gr.

ADULTERATIONS.—Mr. H. Greenish asserts that commercial oxalate of cerium contains a large proportion of the oxalates of lanthanium and didymium, and that the pharmacopœial test does not exclude their presence; this may possibly account for failure in some cases (Med. Record, 1877).

CUPRUM—COPPER, Cu, = 63·4.

This metal (which has its name from Cyprus) is now obtained chiefly from the mines of Cornwall, of the Pyrenees, and of Fahlun in Sweden, in the form of a double sulphide with iron (copper pyrites, Cu_2S, Fe_2S_3): an oxide, a sub- or red oxide (cuprite), and an oxycarbonate (malachite), also occur, as well as arseniates, phosphates, etc.

The metal is extracted from the ores by a process of roasting and fusion; a purer form by electrolytic decomposition of the pure sulphate.

Brass is a compound of copper with zinc (but often contains some *lead*), and bronze is an alloy of copper, tin, and zinc: ordinary commercial copper may contain arsenic.

CHARACTERS AND TESTS. — Copper is the only red metal; it is lustrous, malleable, and ductile, of sp. gr. 8·92; unaltered in dry and cool air, in moist air it becomes coated with hydrated carbonate, and at a red heat is oxidized. In contact with acids, alkalies, or fats, it is readily acted on, with formation of various green compounds, acetates, or oxides, commonly known as verdigris. It is soluble in nitric acid, in sulphuric acid with heat, and in hydrochloric acid if air be present, also in ammonia. It forms cuprous and cupric salts.

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Tests may be remembered by their colour, as (1) *the red test*, shown by immersing clean iron in an acid solution of copper, when the red metal will be deposited; (2) *the blue test*, shown by the coloration produced with excess of ammonia; (3) *the brown test*, by the bulky reddish-brown precipitate which occurs with ferrocyanide of potassium (R. W. Smith).

CUPRI SULPHAS—SULPHATE OF COPPER—BLUE VITRIOL —COPPERAS, OR BLUE STONE, $CuSO_4, 5H_2O$, = 249·4.

PREPARATION.—By dissolving copper in sulphuric acid, with the aid of heat,

$$Cu + 2H_2SO_4, = CuSO_4, + 2H_2O, + SO_2,$$

treating the product with hot water, filtering, and crystallizing.

CHARACTERS AND TESTS.—Occurs in oblique prisms of deep-blue colour, and metallic styptic taste; soluble in 4 parts of cold, and 2 of boiling water, insoluble in alcohol, efflorescing slightly in dry air. The anhydrous salt is *white*, but turns *blue* when moistened with water, and hence serves as a test for the presence of water in absolute alcohol. The sulphate answers to the tests for copper already given, and like other sulphates, gives a white precipitate of sulphate of baryta with barium chloride.

Ammonio-Sulphate of Copper in solution is used as a test for the presence of sulphides in liq. ammoniæ fort., and also as a test for arsenious acid, with which it produces a light-green precipitate of arsenite of copper (Scheele's green).

SUBACETATE OF COPPER—VERDIGRIS—ÆRUGO, $Cu(C_2H_3O_2)_2CuO$.

PREPARATION.—Manufactured by exposing copper plates to the action of pyroligneous acid.

CHARACTERS.—Occurs in powder, or lumps of small crystals, bluish-green in colour, of sour odour and metallic taste. A solution is officinal as a test for butyric acid in valerianate of zinc; the acid is precipitated by it.

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Absorption and Elimination.—Metallic copper, even when powdered, is not usually absorbed. Drouard gave large doses to animals, without any result (Paris, 1802), but when finely divided, some may be rendered soluble by the gastric acids, and traces may be detected in the urine and saliva (Mialhe, Mitscherlich, Portal). Copper coins have often been swallowed with impunity, but profuse salivation is recorded in the case of a child after swallowing a penny (Barton, quoted by Gubler). That the sulphate can be absorbed from wounds has been both affirmed and denied. Langenbeck and Städeler have traced poisonous symptoms to this cause only when fatty acids were present, but Blodig reported vomiting from a single application of cupric caustic to the conjunctiva: such absorption, though it may occur, is certainly not frequent (Husemann). Workers with alloys or salts of copper absorb it, for their secretions, hair, and teeth may be coloured green by it during life; it has been found in their urine, and after death in the bones, and even in the earth in which they are buried (Millon, Bull. Acad. Med., t. xii.). Soluble salts of copper combine with albuminous secretions and form a bluish coagulum; this, when resulting from a salt of an organic acid (as the acetate) is still soluble, but from a salt of a mineral acid (as the sulphate) it is more resistent (Mitscherlich). In any case, only a portion of even a moderate dose is absorbed into the blood, and this probably as an albuminate—the larger portion passes off by the bowel, and appears in the dark-brown fæces as sulphate.

Elimination occurs by the bile, the saliva, and bronchial secretion (Flandrin and Danger, Annales de Thérap., vol. i.): these observers did not detect it in the urine, but others have done so. Elimination is *slow*, for Orfila found copper in the viscera seventy days after its use had been omitted. It is apt to be deposited in the liver especially.

It must be recognized as a very usual constituent of the normal organism. Sargeaux detected it in the blood of many animals, and Odling and Taylor in the liver, kidneys, and other organs, irrespective of poisoning (Guy's Reports, 1866). In the bodies of domestic animals fed on vegetable food Wackenroder found no perceptible amount of copper, but in snails and shell-fish comparatively much; in man and car-

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nivorous animals he found also a rather large proportion both of copper and lead, and concluded that they were derived from the nutritive or medicinal substances taken (Abstract in Brit. and For. Rev., 1855). Odling and Dupré found copper in bread, flour, shell-fish, etc., and in the human liver and kidneys, not invariably, but usually (Guy's Reports, 1858). Stevenson remarked that copper might be derived in the course of an analysis from a copper lamp used for incineration, so that the greatest care is required in such investigations (Lancet, ii., 1872). Schwartzenbach found 0·004 gramme of copper and rather more lead in 2,100 grammes of liver (Brit. and For. Rev., Jan., 1857); Orfila had reported ten times as much. More recently, the average amount found in the entire liver and kidneys in fourteen bodies was 2 to 3 milligrammes ($\frac{1}{30}$ to $\frac{1}{20}$ gr.), and it was found also in the fœtus. The specimens used in the investigation were carefully chosen as not having been exposed to absorption of copper, and the metal was excluded from all apparatus employed. We may therefore conclude that any quantity above 4 milligrammes ($\frac{1}{16}$ gr.) found in these organs is abnormal, and results from direct administration of the drug (Bergeron and l'Hôte, quoted Lancet, i., 1875, p. 255). In the case of the two wives of Moreau, 120 milligrammes and 80 milligrammes were found respectively (B. M. J., ii., 1874, and i., 1875). In a case where ammonio-sulphate of copper had been taken three months before death, nearly 300 milligrammes (4½ gr.) were obtained from the liver, a good instance of its slow elimination (Bournevette and Yvon, Rev. Scientifique, 1874, p. 859). Rabuteau found 16 centigrammes (2½ gr.) in 1,000 grammes liver also three months after the last dose—43 grammes in all of ammonio-sulphate had been taken (Gaz. Hebdom., March, 1877).

PHYSIOLOGICAL ACTION.—*External.*—The sulphate, which is the salt most commonly used, has little action on the sound skin, but when applied to wounds or mucous membranes, it coagulates the albumen, and forms a thin film on the surface. The pure salt, or its concentrated solution, acts as a caustic; weaker solutions act as stimulants and astringents, both forms producing more or less condensation of the neighbouring tissues.

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They exert, also, some antiseptic power, partly by decomposing sulphuretted hydrogen, and partly by destroying low organisms, whether animal or vegetable. Any conclusions drawn from the effects of the smoke and vapours of copper foundries are rendered doubtful by the co-existence of sulphurous acid, arsenic, etc. Vegetable life of all kinds is destroyed in the immediate neighbourhood of such works.

PHYSIOLOGICAL ACTION.—*Internal.*—Digestive System.—In the lower animals, salts of copper seem to be uncertain in their effects, at least when given by the mouth. According to Orfila, vomiting is the earliest and most marked symptom, and Drouard found that 12 gr. of sulphate caused fatal gastric inflammation in dogs. On the other hand, Galippi could not poison dogs with pure copper salts, for small doses were tolerated, and large ones were so nauseous that he could not get enough swallowed or retained (Bull. de Thérap., 1875). Ducom and Burq also report that dogs can take from 15 to 60 gr. daily of soluble salts of copper for a varying time without ill-effect on the general condition, with the exception of vomiting at first; long-continuance of this medication at length impaired appetite and digestion, and thus led to death from exhaustion (Bull. de Thérap., 1875).

In man, small doses (¼ gr.) of a soluble salt of copper exert a tonic astringent action, but if continued for a long time impair appetite and digestion, and cause diarrhœa from irritation. The effects of frequently-repeated minute doses have lately excited special attention, on account of the adulteration with copper of many preserved vegetables. Thus, in the French preserved *green peas*, 0·31 to 0·56 gr. has been found in each tin, and by some chemists, and even medical men, this quantity has been pronounced injurious (M. Pasteur and others, B. M. J., 1876-77). Vulpian, however, says that any copper compound contained is insoluble and harmless, and that no evidence exists to the contrary; and Galippe, after the crucial test of eating them freely for some time, found no bad result (B. M. J., i., 1877). In a 4 lb. loaf of bread ·4 to 1·8 gr. has been found, and the latter amount might become serious (Med. Times, i., 1871, p. 509). Doses of 1 to 3 gr. induce a sense of constriction in

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the gullet, and vomiting occurs in a few minutes without much nausea, and is commonly attended with diarrhœa; 5 to 15 gr. act as a powerful irritant emetic.

Lauder Brunton and West have experimented to ascertain whether cupric salts cause vomiting by irritation of the stomach or of the vomitive centre in the medulla. Into the jugular vein of cats they injected a neutral albuminate of copper (which would not cause coagulation of blood), and retching and vomiting followed. Previous section of the vagi did not prevent the retching, but it did prevent evacuation of the stomach, and after section of the vagi and the splanchnic nerves neither retching nor vomiting occurred: hence they conclude that these symptoms depend upon gastro-intestinal irritation, not upon a direct excitement of the central organs (Barth. Hosp. Rep., 1876).

Toxic Action.—Half an ounce given at one time by the mouth produces severe symptoms of irritant poisoning, including metallic taste, feeling of constriction, thirst, salivation, nausea, vomiting, purging, and severe cramping pain with tenesmus; the abdomen is distended and tender, the evacuations greenish or containing blood; the face may be flushed and swollen, the gums ulcerated, and sometimes jaundice occurs; death may follow from enteritis or exhaustion within a few hours or days. From 1 to 2 oz. of sulphate or acetate may be reckoned a fatal dose, though recovery has occurred after 5 oz., when vomiting has been free (Toussaint and others); in practice a fatal issue is rare.

Blandet asserts that *enteritis*, though commonly produced by carbonate or acetate of copper, does not occur from the sulphate, and in one case, where 300 gr. were taken, vomiting, suppression of urine, and subsultus occurred, yet recovery took place without enteritis (Med. Times, i., 1874); the danger of the drug has doubtless been exaggerated, and Hönerkopf gave in seventy-two cases, 5 grammes, and in eighteen cases, nearly 3 grammes without injury, but in other cases enteritis has been caused by it.

Acute copper-poisoning occurs most often from accidental contamination of food cooked in copper vessels, which, when perfectly clean and pure, are not harmful, but *under* the influence

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of air and moisture, vinegar, salt, or hot fats, carbonate, acetate, and oxychlorides of copper are formed, and the admixture of these salts ("verdigris") with the food is exceedingly injurious, causing severe colic, vomiting, headache, and pyrexia; tympanitis is sometimes very marked, and numbness and tremor of the limbs have been noted (Taylor, Armstrong, Med. Times, 1844). Similar symptoms, with scanty urine and excoriations about the mouth, followed the use of water boiled in a copper kettle, and of injections from a brass syringe (Amyot, Med. Times, 1859, Boggs, Lancet, 1869). An epidemic, much resembling dysentery, occurred on board an Indian emigrant ship from using copper for the cooking of rice with ghee or butter (Moore, Lancet, 1846). If only one portion of the contaminated food has been taken recovery is usually rapid and complete, in proportion to the amount of vomiting; but if more be taken and not rejected, there remains a tendency to colic, vomiting, or diarrhœa, with much debility. Should death follow, there will be found intense redness of the intestinal tract or actual ulceration, according to the stage of the poisoning; perforation is rare (Taylor).

Chronic Copper-Poisoning—"*Cuprismus Chronicus.*"—Whilst by some observers this condition has been described as marked and frequent, by others its existence has been denied, and the symptoms explained by adulteration with lead, etc. The truth lies between extreme views—some amount of copper-poisoning may be traced amongst workers with the metal, but it is not very serious. Working in pure metallic copper without heat causes no bad symptoms (Hirt, Maisonneuve), but particles of oxide and cupric salts in the air of heated rooms may induce dyspnœa and laryngeal spasm. "Gold-printers," working with brass-alloy in fine powder, sometimes get vomiting, gastric pain, and anæmia; the hair becomes green-coloured (Taylor). Dr. G. Harley has described a case of sudden colic with nausea, but neither diarrhœa nor constipation, in a copper-plate printer after cleaning plates coated with verdigris: there was a purple line on the gums (Lancet, 1863). Blandet was the first to describe a more serious chronic cuprismus as existent in Paris workshops, and marked, besides the green coloration, by colic with remissions, fever, lassitude, nausea, bilious vomiting, and

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diarrhœa alternating with constipation (Gaz. Méd., 1845). Sir D. Corrigan recorded seven instances in brass-founders and engineers with similar symptoms, also emaciation, cough, and night-sweats; but two of these had organic lung-disease, and the cases are not conclusive (Dub. Hosp. Gaz., 1854). A band of light or reddish-purple on the gum-margin is described as characteristic, but really indicates an *inflammatory* condition which may arise from other causes (Bucquoy, Union Méd., i., 1874). Bailly describes the true copper bluish-green or blue line as on the *teeth* only, not on the gum, which, however, was commonly inflamed: by analysis he detected copper in the blue line. Perron reported the prevalence of dyspepsia, "enteritis," and phthisis, amongst Swiss watchmakers working with an alloy of gold and copper; they had green coloration of the teeth, but mal-hygiene was a more likely explanation of their impaired health (Med. Times, 1861). Dr. Clapton brought before the Clinical Society cases of irritative dyspepsia in a flower-girl and a copper-smith, but his inquiries about copper-workers verified the absence of any special disease amongst them (Transactions, vol. iii.). Chevallier, after an exhaustive inquiry, concluded Blandet's statement to be exaggerated, and failed to verify a true "copper colic" (Annales d'Hygiène, 1859); any severe cases were found complicated by the presence of lead in the material used. Christison and Chomel reached the same conclusion. Hirt, whilst allowing that verdigris-makers may suffer from intestinal catarrh, and even from some amount of paralysis, blames rather lead, zinc, or arsenic in observed cases of severe "colic." I have known brass-founders get periodic attacks of colic and vomiting followed by rigors—a condition known in the workshops as "brass-founders' ague," and induced when the alloy is melted, and they are much exposed to its vapour—but have connected it rather with zinc or arsenic than copper. Pécholier and Pietra Santa, reporting on the health of verdigris-workers, describe local irritation of mucous membranes, but otherwise good health: they note especially the absence of colic and of chlorosis (Med. Times, 1864); and Maisonneuve concluded that though gastro-intestinal disorder may be induced by such work, the symptoms are neither severe nor persistent (Ranking, i., 1865).

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Pathological Changes.—In animals that had taken copper for a long time Mair observed softening and degeneration of the liver, and in one case of poisoning by the sulphate Maschka attributed the jaundice to fatty degeneration. The kidneys were similarly affected (Syd. Soc. Year Book, 1873).

Nervo-Muscular System.—If ¼ gr. of oxide of copper be injected under the skin of a rabbit, there will quickly follow unsteadiness in walking, which will gradually pass into complete motor paralysis: the respirations and pulse become feeble, and muscular irritability becomes less, till finally death occurs from paralysis of respiratory muscles (Harnack, Schmidt's Jahrb., 1874). Falck noted very similar effects, with fall of temperature and progressive general paresis, ending in death from cardiac palsy, after hypodermic injection of sulphate, nitrate, and chlorate of copper (Deutsches Klinik, 1859); sensation was unimpaired, and the paralysis was limited to striped muscular tissue.

It has been remarked that many *emetic* medicines, *e.g.*, antimony and apomorphia, produce also muscular paralysis, and there may be some direct connection between it and severe vomiting: in Falck's experiments, however (with hypodermic injections), vomiting was not produced. In cases of acute copper-poisoning in men the nerve-symptoms are such as headache, giddiness, prostration, restlessness, tremor, subsultus tendinum, convulsion alternating with stupor or comparative clearness of mind, and sometimes a motor or sensory palsy, partial and temporary in character: such symptoms are mainly secondary to the gastric irritation.

Respiratory and other Systems.—There is not much to be said about the special action of copper on other parts of the body, but in the course of acute poisoning, respiration becomes hurried and laboured, the pulse small and usually quickened, and the extremities cold; suppression of urine has been recorded, but amongst workers in copper, absorbing slight amounts daily, *diuresis* was a usual symptom (Clapton).

SYNERGISTS.—Salts of lead and zinc, silver and gold, are allied in action to those of copper. Depressing vital conditions favour the development of its irritant properties.

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ANTAGONISTS — INCOMPATIBLES. — Metallic sulphides, alkalies, and alkaline earths, iodides, and vegetable infusions containing tannin, are chemically incompatible with salts of copper: sugar also reduces them. In cases of poisoning, the action of sugar is too slow to be effective, and magnesia, though it may retard bad effects, does not wholly prevent them, since the hydrated oxide of copper is soluble. Sulphide of iron decomposes copper salts, forming an insoluble cupric sulphide, and may be used, but the best antidote is said to be ferrocyanide of potassium (yellow prussiate of potash), which should be given freely: the resulting copper salt is insoluble (Med. Times, ii., 1854). Albumen, which may be given in the form of egg and milk, forms an albuminate of copper, but this is not inert and should be removed afterwards by the stomach-pump (Schroeder). In phosphorus-poisoning, copper, though praised by Bamberger, is not so good as turpentine (*v.* pp. 55, 56).

THERAPEUTICAL ACTION.—*External.*—Applied in lotion, ointment, powder, or crystal, sulphate of copper, "blue-stone," or "blue-vitriol," acts as a stimulating astringent, or a moderately severe caustic. It unites with albuminous secretions to form an insoluble albuminate of copper, which, acting like a new cuticle, protects the injured part from the atmosphere, and promotes the healing process. Equal parts of sulphate of copper, alum, and nitre, fused with four parts of camphor, form a caustic of some celebrity known as "lapis divinus," or green-stone.

Tinea Tarsi—Trachoma.—In these chronic, recurrent disorders of the eye-lashes and lids, the crusts and muco-purulent discharge, and in severe cases the lashes, should be carefully removed, and a crystal of copper sulphate lightly applied to the affected parts. This treatment has the recommendation of Sir W. Wilde (Dub. Quart. Journ., No. 10), of Galezowski, and other authorities, and Mr. Williams (Boston) has published good practical instructions concerning it (Ranking, ii., 1870). I myself commonly prefer this remedy to either zinc or silver, since it is milder, and causes less pain; I generally combine with it the use of a dilute mercurial ointment.

Aphthous Stomatitis.—Sulphate of copper, either applied lightly in substance, or brushed over the affected part in

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strong solution, removes the white curdy deposit and induces healing of abrasions and ulcerations about the gums: 10 gr. mixed with about 1 oz. of honey is a good form for its use in children. Sir James Paget recommends a gargle containing 1 to 2 gr. of sulphate in 1 oz. of water, as useful in salivation, free purging being secured at the same time (Med. Times, i., 1858). A similar lotion will destroy diphtheritic membrane.

Indolent Ulcer—Rectal Ulceration.—The solid crystal of the sulphate is a good stimulant to indolent ulcers, and a good caustic for exuberant granulations. Dissolved and used as an injection it is of service in various forms of ulceration affecting the rectum, especially, according to Mr. C. Heath's experience, in the later syphilitic forms, when the dorsal surface, or sometimes the whole circumference of the bowel within two inches of the anus, is affected, and there is much muco-purulent discharge. For such cases Mr. Heath recommends an injection containing about 10 gr. of sulphate to the pint, a fourth part to be used at one time, and retained for ten minutes: this has an excellent astringent effect, and should be combined with the use of mercurial ointments locally, and iodides internally (Lancet, i., 1873).

Cancer.—The arsenite of copper is said to be a valuable application for cancerous sores. Mr. Taylor (Liverpool) used it with an equal part of mucilage, and found it a good escharotic, disinfectant, and at the same time sedative dressing (Lancet, ii., 1864); it has not, however, been much used.

Skin-Diseases.—In parasitic cases, such as ringworm and scabies, the sulphate of copper has been applied with success: in the former Dr. Graves recommended a wash containing 10 gr. in the ounce, a strength which may, with advantage, be doubled: an ointment containing a similar proportion mixed with lard has cured scabies (Lancet, i., 1846). In ichthyosis, this ointment has also been recommended by Mr. E. Wilson, and the solid crystal is often used for verruca (wart) and molluscum.

Gonorrhœa—Leucorrhœa—Gleet.—In these disorders an injection containing sulphate of copper, 1 to 2 gr. in the ounce, is often a useful alternative to injections of zinc or lead, or it

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may be combined especially with the acetate of lead. Dewees and also Diday have shown the value of cupric injections in such cases (Archives Gén., xviii., p. 385), and Dr. P. Foster has more recently illustrated the same (Med. Times, ii., 1873). In balanitis a copper lotion is useful.

Bubo, etc.—Good results have been obtained after surgical evacution of a suppurating bubo, from injecting a weak solution of copper sulphate into the cavity. M. Danielli found this quickly diminish the secretion, which after simple opening is very apt to re-form (Bull. de Thérap., 1868). M. Diday recommended a strength of 3 gr. to the ounce. The solid sulphate is a good application to syphilitic cracks, patches, and ulceration about the mouth and tongue.

Hydrocele.—As an injection for hydrocele, 2 to 8 parts of sulphate in 200 to 250 of water have been used with success. Dr. Pereira (Oporto) states that twenty-one out of twenty-five cases were cured with this treatment (Med. Times, i., 1861).

Caries—Fistulous Tracts.—Strong stimulating and astringent lotions are sometimes of service in these conditions, especially after the carious bone has been removed or the fistula divided. The "liquor Villati" has been much used abroad in such cases without previous operation. It is made with ½ oz. of sulphate of copper and of zinc, and 1 oz. of lead subacetate, dissolved in 7 oz. of vinegar; M. Notta and M. Nélaton have used this with advantage, but it is painful, and should not be injected more than two or three times in a week (Union Méd., 1866).

THERAPEUTICAL ACTION.—*Internal.*—In small doses the salts of copper exert a tonic influence upon the nervous system, and an astringent effect on mucous membranes, whilst doses of 1 gr. and upwards are emetic. The salts in question clearly resemble in action those of zinc, but are somewhat more irritant.

Chorea.—Although preparations of copper are not now much used in this affection, I can refer to some very good results from the sulphate in my own experience, and especially in cases connected with tænia and other intestinal worms. I think it well worthy of use in cases where there is

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even a suspicion of their existence; it will aid their expulsion if present, and in any case act as a good nervine tonic. I have seen permanent good results from ¼ gr. given three times daily, though sometimes this dose needs to be gradually increased.

Hysteria.—In some cases of hysteria, with general debility, shyness, muscular twitching, etc., marked benefit may be derived from the same treatment.

Epilepsy.—It is probable that of the older cases called epilepsy, and reported as cured by copper, a large proportion were hysterical, but Voisin reports from the practice of Herpin (Geneva) several illustrations of its power to cure chronic and obstinate cases of true epilepsy. He generally used the ammonio-sulphate alone, or alternately with zinc, for many months; the cure continued permanent some years afterwards (Bull. de Thérap., i., 1870). Halford made great use of copper combined with quinine in this malady (Med. Times, i., 1858), but general experience is not in its favour. Charcot has published a case carefully treated for three months with full doses of the ammonio-sulphate, but the convulsive attacks were rather increased during its use (B. M. J., i., 1875). I have given the sulphate and the acetate in varying doses and for long periods in many cases, but have not seen benefit from them in true epilepy, although for epileptiform attacks dependent upon intestinal worms, they have several times proved useful.

Spasmodic Asthma.—In cases where there occur well-marked paroxysms, terminating in the ejection of quantities of mucus, small doses of sulphate of copper, repeated frequently until vomiting occurs will usually give relief; but independently of vomiting, in asthma of more purely nervous type, I have observed benefit from ⅛ gr. and upwards, given every one to three hours during the attacks, and continued night and morning in the intervals, so as to secure a tonic effect on the nervous system.

Whooping-Cough, in the early spasmodic stage, is often relieved by the same remedy, especially if moderate emesis be produced.

Emphysema—Chronic Bronchitis.—I have seen relief given to the dyspnœa dependent on these conditions by small doses of sulphate of copper continued for some time. I believe it acts partly through the nervous system, and partly like other

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astringents, by lessening the amount of secretion in the bronchi, and so permitting free access of air.

Tapeworm.—I have often known tæniæ dislodged and passed under the use of small doses of the sulphate; about $\frac{1}{6}$ gr. in solution is a suitable amount to commence with, and may be given every morning, fasting. If this dose be steadily and gradually increased, upwards of 3 to 5 gr. may be administered without causing vomiting or purging; but should these symptoms occur, the medicine is better omitted for the time, to be resumed in smaller doses if required again. This treatment should be continued for eight to ten days or longer, an occasional dose of castor oil being given when necessary.

Chronic Diarrhœa and Dysentery.—Sulphate of copper is an excellent remedy in these disorders, given in doses of $\frac{1}{2}$ to 1 gr., three or four times daily. Elliotson highly recommended it in somewhat larger doses, and generally combined with opium in a pill (Med.-Chir. Trans., vol. xiii.), but if opium be really required for pain, I find it better given separately, especially in the form of Dover's powder, at bed-time. Morehead also recommends this treatment (Diseases of India, i.). In *infantile* diarrhœa, objection has been taken to the use of copper, but I have seen it act most beneficially in obstinate cases, not only when chronic, but also when acute in character, and especially when connected with dentition—the dose may vary from $\frac{1}{60}$ to $\frac{1}{4}$ gr. several times daily. Pereira specially recommends the remedy in $\frac{1}{12}$-gr. dose. Eisenmann has also recorded its value in the diarrhœa of dentition, and of weaning, and states that he has seen many cases treated by it and cured, when others, not so treated, have become chronic and ended in marasmus (Bulletin, June 30, 1859).

In the *diarrhœa of phthisis*, dependent, as it commonly is, on ulceration of the intestine, we often require to use different forms of astringents, and the sulphate of copper is a valuable alternative. Small doses only should be used, in order to avoid nausea and irritation—$\frac{1}{4}$ gr. with the same quantity of opium is advised by Sir T. Watson (Lectures, ii., p. 216.).

In Enteric Fever with severe diarrhœa, a similar combination is highly praised by Dr. John Harley (Reynolds' System, i., p. 419), who "considers it more efficacious than any other

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medicine." The dose may be increased up to 1 gr., but must be kept small enough to avoid vomiting; quite small doses rather allay gastric irritability.

Cholera.—In this malady, the sulphate has been considered by some physicians so valuable as to be almost a specific. I cannot place great reliance upon it, though I have sometimes observed it relieve the cramps, the retching and purging, and strengthen the weak intermittent pulse, and assist in warding off collapse. The careful observations of Gutmann have rendered improbable any specific action of the drug.

Some *prophylactic* power against cholera has been claimed for copper, for the neighbourhood of towns where large copper-works are situated, such as Swansea, Birmingham, Rio Tinto, has been markedly free from the disease, but other circumstances, and other components of the vapour, such as sulphurous acid, must be taken into consideration (Med. Times, ii., 1854, ii., 1871). A similar immunity is recorded at the large powder factory at Madras, where the mixed chemicals are said to be exposed to a temperature of 500° F., which would be sufficient to develop sulphurous acid from the sulphur (Mr. Parker, Lancet, ii., 1873). More important is the fact, that amongst more than 5,000 copper-workers in Paris, not one was attacked by cholera, during an epidemic which affected other workmen in the proportion of about 1 in every 140; and of the former, not one died of cholera in the course of five epidemics (Burq, Lancet, ii., 1873). Dr. Clapton also remarked that the copper-workers seemed to have almost complete immunity from cholera and from choleraic diarrhœa, when it was very prevalent amongst the neighbours, and the same observation has been made by others. Still, such prophylactic virtue of copper is not usually recognized, perhaps because it is difficult to understand, but Dr. Clapton suggests as some explanation, the disinfectant power of the metal, and its destructive action upon fungi; the subject deserves further investigation.

Croup (Laryngo-Tracheal Diphtheria).—In this malady the sulphate of copper has been highly esteemed, especially by German and French physicians, since its first introduction by Hoffmann; he used it mainly as an emetic, but the question has arisen whether it does not exert a *specific* action upon the

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false membrane. Kissel, who reports successful cases from the use of non-emetic doses of the acetate, supports this view (Journ. f. Pharmaco-dynamik.), and Missoux, who also speaks highly of the remedy, but who gave 5-gr. doses, argues in favour of specific action, because the false membrane, after becoming detached, either does not form again, or if it does so is no longer so plastic, tough, and adherent (Bull. de Thérap, Dec. 1858, abstract in Med.-Chir. Rev., ii., 1859). In judging of the curative results, we must bear in mind the distinction between simple catarrhal laryngitis and the membranous form (true croup), since the former is more likely than the latter to have a favourable issue independently of treatment, but allowing for this, there can be no doubt that most of the cases of Godfrey and of Beringuier were of the more serious malady; these observers used emetic doses (2 to 4 gr.) and also depletion. Trousseau used it mainly as an emetic, in doses of 5 gr., twice repeated (Gaz. des Hôp., No. 39). I do not ignore the six fatal cases recorded by Dr. Hannay (Lond. Med. Gaz., July, 1840), nor the adverse opinion of Nothnagel, who fears its injurious effects on the intestinal tract, but still I consider the remedy of value. Dr. Crighton states (Edin. Med. Journ., May, 1868) that out of fifty cases of croup treated by him with the sulphate, only six died; he gave ½ gr. every ten to fifteen minutes till vomiting or marked relief occurred; but even these doses are rather large for children, and, in fact, he records that two of them had violent diarrhœa. I recommend doses of $\frac{1}{8}$ to $\frac{1}{4}$ gr. for children, to be given every quarter to half hour until vomiting is induced; then the dose should be diminished and given at longer intervals so as to avoid too severe effects, and later it may be increased again should it become necessary to produce emesis. This plan may be adopted in true croup during the stage of development of the membrane when there is a dry barking cough, and sense of constriction across the chest, with much difficulty of respiration: and it is also serviceable in cases where a loose catarrhal cough assumes a dry croupy character, when there is partial aphonia, and often some sanguineous discharge from the throat and nostril.

The following notes of an illustrative case have been furnished to me by Dr. Mackey:—E. S., a girl, aged three, was hoarse on

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April 7th; on the 9th became feverish and restless, with hurried, loud, and stridulous respiration, and clutching at the throat; there was no exudation on tonsils: has had castor oil, poultices, and steaming, now ordered 6 min. of ipecacuanha and 6 of antimonial wine every hour: vomited after the third dose, but the oppression continuing, a teaspoonful of the ipecacuanha wine was given and caused freer vomiting.

On the 10th there was, however, no relief, the stridulous croupy breathing being more marked, the face flushed, not very dusky; pulse 120, resp. 36; drowsy, yet restless. (10 a.m.): to omit other treatment and take ½ gr. of copper sulphate every half-hour in water. (1·30 p.m.): has had four doses; vomited freely after the first two, and slept comfortably; is better, pulse 110, resp. 32. (6 p.m.): one dose since; vomited and moderately purged; pulse 110, resp. 28, temp. 100; speaks better, and smiles. (11th, 9 a.m.): has slept fairly well, lying down; had two doses, and vomited after each; looks much better; resp. 32, temp. 98; bowels moved once. 12th: Convalescent, though still some stridor when asleep; an occasional dose of the copper relieves sensibly. The child got quite well.

Diphtheria.—In the ordinary form of diphtheria the sulphate of copper has also been found useful by some observers. Dr. W. Squire speaks of it as one of the most effectual emetics, and recommends a solution of 5 gr. to the ounce to be given in divided doses—a teaspoonful only to young children, so as to induce moderate vomiting (Reynolds' System, i., p. 147, 2nd Ed.). In cases of formation of diphtheritic membrane on the cutaneous, or nasal, or vulvar surface, lotions of the sulphate are found to destroy it, and to prevent its re-formation.

Intermittent Fever.—In obstinate quartans, more particularly, the salt has been commended by Hoffmann, Chapman, and others, in ¼-gr. doses, combined with opium, but it has not come into general use.

Phosphorus-Poisoning.—Bamberger, Eulenburg, and others have recommended the sulphate as an antidote in this form of poisoning, which is not uncommon in Germany; the salt certainly is reduced by phosphorus, and it is supposed that the latter may be coated with the metal, and thus rendered inert (*v.* p. 55): an emetic effect also is serviceable, as it

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is also in narcotic and other cases of poisoning (Nothnagel, p. 333).

Syphilis.—Aimé Martin and Oberlin have recently published the results of fifty cases of secondary and tertiary syphilitic affections treated with sulphate of copper; in many of these it is said to have acted more promptly than mercury; only in one patient vomiting took place on the first day, but very soon the metal was borne well; a green margin of the gums without an inflamed state of the mucous membrane was observed in a few cases, but disappeared soon; the remedy was given in solution, and 4 to 8 or 12 milligrammes were used daily. To a full bath 20 grammes were added (Gaz. Méd. de Paris, Nov. 15, 1880). Zeissl has tried copper in syphilis, but his results were only partly satisfactory (Wien. Med. Presse, Nov. 29, 1880).

PREPARATIONS AND DOSE.—*Cupri sulphas:* as a tonic and astringent, ¼ gr. to 1 or 2 gr.; as emetic, 5 to 8 gr. (for adults)—best administered in divided doses at short intervals; a child may have ⅛ to ¼ gr., according to age and strength, repeated every five to fifteen minutes till vomiting occur, it should then be omitted for a time, or purging may succeed. The *oxide* of copper has been used in doses of ¼ to 1 or 2 gr., and the *double chloride* with ammonium in ¼ or ½-gr. doses, every two or three hours. A *tinctura cupri acetici* has obtained some favour on the Continent under the auspices of Rademacher. It is prepared by mixing 24 parts of copper with 30 parts of acetate of lead in 136 parts of distilled water: boiling this in copper vessels, then adding 104 parts of spirit, and macerating for four weeks in a closed glass vessel, then filtering. It forms a green liquid of metallic taste, and is the chief remedy for all "copper diseases," and "especially for hyperæmiæ, stases, and exudations"—5 to 15 drops and upwards are given thrice daily (Kissel, Husemann). *As a lotion*, 1 to 2 gr. of sulphate in the ounce, *as a parasiticide*, 10 to 20 gr. to the ounce may be used, and a stimulating astringent *ointment* may be made with ung. sambuci in the same proportion.

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FERRUM—IRON, Fe, = 56.

Iron, the most abundant and the most useful of metals, occurs extensively in the mineral kingdom, its principal ores being either oxides, as the magnetic iron ore, or carbonates, as clay iron-stone. It occurs also in many mineral, so-called *chalybeate* waters, generally as carbonate with excess of carbonic acid, sometimes as ferrous chloride or sulphate. In the animal kingdom it is an essential constituent of blood, being contained, though only in minute quantity, in the hæmoglobin of the red corpuscles. It occurs largely also in the vegetable kingdom, and may be traced in the ashes of almost all plants. Sometimes the pure metal is found native, and is then commonly supposed to be of meteoric origin.

CHARACTERS AND TESTS.—Iron is hard, malleable, ductile, and of great tenacity; sp. gr. 7·7. Exposed to moist air, it becomes covered with a reddish layer—rust—which is mainly hydrated sesquioxide. It forms two distinct classes of compounds known as proto- or ferrous salts, and per- or ferric salts; in the former, it combines with not more than two atoms of a monad, as Cl or I; in the latter, it requires three, or, as most consider, six atoms of a monad for saturation (Smith's Commentary). *The ferrous or proto-salts* are commonly lighter in colour, less astringent, and less soluble in alcohol; they have a marked tendency to absorb oxygen, and to become ferric compounds, hence most of the officinal ferrous salts are in a partially oxidized state, but to some, sugar is added to prevent such change as in syrupus ferri iodidi, and ferri carbonas saccharata. *Ferric or per-salts* are generally brownish-yellow, astringent, and soluble in alcohol, and are not prone to change: within the body, however, they are probably reduced to proto-salts.

The general tests for iron are—(1) the colour test, with tannic or gallic acid; (2) the precipitate and blue colour produced by ferro-cyanide; and (3) by ferrid-cyanide of potash. (1) Tannins change the per-salts of iron bluish-black, and act similarly, though more slowly, with proto-salts. (2) The yellow-prussiate

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of potash (ferro-cyanide) gives a deep blue precipitate with per-salts of iron, and a whitish or light-blue one with proto-salts. (3) The red prussiate (ferrid-cyanide) gives no precipitate with the per-salts, but the liquid becomes of a dark colour: a deep-blue precipitate with proto-salts (Turnbull's blue).

Sulphuretted hydrogen and ammonium sulphide are also used as tests for iron salts; thus, in acid solutions of pure *ferrous* salts, the former gives no precipitate, whilst with *ferric* salts it throws down a nearly white precipitate of sulphur, with reduction to the ferrous state:—$Fe_2Cl_6 + H_2S = 2FeCl_2 + 2HCl + S$. The same tests will also precipitate any copper contained in acid solutions of iron salts.

By acids iron is readily dissolved, with formation of metallic salts and evolution of hydrogen.

COMPOUNDS OF IRON.

The large number of officinal iron compounds may be with advantage considered in the following order:—The preparations of the metal itself and its oxides; the astringent preparations; and those which are not at all, or not markedly, astringent.

FERRUM REDACTUM—REDUCED IRON[1]*—QUEVENNE'S IRON.*

Metallic iron is introduced in the form of soft or wrought iron-wire, or nails free from rust, and also combined with some oxide, as ferrum redactum.

PREPARATION.—By passing a stream of hydrogen at red heat over the hydrated peroxide—$Fe_2O_3H_2O + H_6 = 4H_2O + Fe_2$. At the same time, by incomplete reduction, some magnetic oxide is formed—$3Fe_2O_3 + H_2 = 2Fe_3O_4 + H_2O$.

CHARACTERS.—Pure reduced iron is an impalpable greyish-black powder, strongly magnetic, and showing metallic streaks on firm pressure. The oxide can be separated from the metal, and its amount ascertained by digestion with iodine and iodide

[1] "Reduced" iron means the metal minutely divided by chemical process as distinguished from simple filings or powder (mechanical division); the percentage of metal in this form is often small (Pharm. Journ., Aug., 1875).

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of potassium, which dissolves the metal alone; of this, it should contain at least 50 per cent.; a little sulphide is sometimes present, and is liable to cause disagreeable eructation.

FERRI OXIDUM MAGNETICUM—MAGNETIC OXIDE OF IRON, Fe_3O_4, = 232.

Black oxide—containing about 20 per cent. of water.

PREPARATION.—This being a mixture of proto- and per-oxide, is prepared by adding a mixed solution of proto- and persulphate of iron to an excess of soda; the precipitate is washed and dried at a moderate temperature (120°), for at a greater heat it would absorb oxygen.

CHARACTERS AND TESTS.—A brownish-black powder, tasteless, strongly magnetic, and soluble in acids without effervescence: bubbles of hydrogen would show the presence of metallic iron.

FERRI PEROXIDUM HUMIDUM—MOIST PEROXIDE OF IRON, $Fe_2 6HO$, = 214.

PREPARATION.—By pouring solution of persulphate of iron into excess of soda, and washing away the sodium sulphate: a similar precipitate would be thrown down by potash or ammonia.

CHARACTERS.—A pasty mass, reddish-brown in colour, and containing water, both combined and uncombined, to the amount of nearly 90 per cent: it is the only iron preparation used in the moist state: it dissolves readily in cold dilute hydrochloric acid.

FERRI PEROXIDUM HYDRATUM—HYDRATED PEROXIDE OF IRON, $Fe_2O_3H_2O$, = 178.

PREPARATION.—By drying the moist peroxide last described at a temperature of 212°, and reducing to powder.

CHARACTERS.—A tasteless powder, distinguished from the magnetic oxide by its dark-brown colour, and its being non-magnetic.

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(The astringent preparations of iron are mainly those which are formed by direct solution of the metal in the strong mineral acids, and include the chloride, nitrate, and sulphate.)

LIQUOR FERRI PERCHLORIDI FORTIOR—STRONGER SOLUTION OF PERCHLORIDE OF IRON, (Fe_2Cl_6,) = 325.

PREPARATION.—By dissolving iron wire in an excess of hydrochloric acid (by which a ferrous chloride is obtained), and treating this with nitric acid to peroxidation—thus

$$Fe + 2HCl = FeCl_2 + H_2.$$
$$6FeCl_2 + 2HNO_3 + 6HCl = 3Fe_2Cl_6 + 2NO + 4H_2O.$$

Sufficient distilled water is added to give a sp. gr. of 1·44. The per-salt could not be formed by the first-mentioned acid alone, because the nascent hydrogen which is set free, reduces ferric salts to the ferrous state.

CHARACTERS.—The liquid is at first black from the combination of some nitric oxide (NO) with ferrous salt, but on heating the mixture the gas is expelled, and an orange-brown solution remains: it generally contains some free acid, and has a very strong styptic taste.

Liquor et Tinctura Ferri Perchloridi (*v.* p. 616).

LIQUOR FERRI PERNITRATIS—SOLUTION OF PERNITRATE OF IRON, $Fe_2 6NO_3$, = 484.

PREPARATION, etc.—By dissolving iron wire in nitric acid, and diluting to the proper strength, and a sp. gr. of 1·107. It is a clear solution of reddish-brown colour, acid and astringent.

LIQUOR FERRI PERSULPHATIS—SOLUTION OF PERSULPHATE OF IRON, $Fe_2 3SO_4$, = 400.

PREPARATION, etc.—By boiling a solution of the protosulphate with some additional sulphuric and some nitric acid. A dense solution of reddish-brown colour; very astringent.

FERRI SULPHAS—SULPHATE OF IRON, $FeSO_4 7H_2O$.

The *proto-sulphate of iron* is the salt from which the greater number of the other compounds are prepared. Three forms of

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it are officinal—ferri sulphas (green vitriol), ferri sulphas exsiccata, and ferri sulphas granulata.

PREPARATION.—By dissolving iron wire in dilute sulphuric acid, and crystallizing.

CHARACTERS.—The *sulphate* occurs in oblique rhombic prisms, of greenish blue colour and very styptic taste, soluble in water, insoluble in spirit. Exposed to air, it absorbs oxygen and turns brown from formation of ferric sulphate: if the crystals be rich green in colour, some ferric oxide is present, but if nearly free from any ferric salt, the precipitate with yellow prussiate of potash will be nearly white. The crystals effloresce slightly in dry air; at 238° F. they lose most of their water of crystallization, and at 400° only one atom of water is retained, and the salt becomes a yellowish-grey powder.

Ferri Sulphas Exsiccata—Dried Sulphate of Iron ($FeSO_4H_2O$). This does not alter on exposure, and is not gritty: 3 gr. are equal to 5 gr. of the crystallized salt.

FERRI SULPHAS GRANULATA—GRANULATED SULPHATE OF IRON.

PREPARATION.—By filtering a boiling solution of ordinary sulphate into cold rectified spirit, constantly stirring.

CHARACTERS.—Occurs in small green granules which are stable, and if carefully dried retain their properties many years.

TINCTURA FERRI ACETATIS—TINCTURE OF ACETATE OF IRON.

PREPARATION.—By adding an alcoholic solution of acetate of potash to one of persulphate of iron, agitating for an hour, and filtering from the precipitate of sulphate of potash, which is insoluble in spirit.

CHARACTERS.—A deep-red liquid which is apt to decompose and become muddy; its taste is not unpleasant, and its degree of astringency moderate.

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FERRI CARBONAS SACCHARATA—SACCHARATED CARBONATE OF IRON, $FeCO_3$, = 116.

PREPARATION.—By adding carbonate of ammonium to ferrous sulphate, each salt being dissolved in boiling water, so as to avoid the presence of air; the precipitate is collected, washed, and rubbed with sugar.

CHARACTERS.—The precipitate is at first white, then green and finally becomes red from absorption of oxygen and formation of ferric oxide. There is no *ferric* carbonate, but what is often sold as carbonate is a brown ferric oxyhydrate containing only a trace of the desired salt, which is very unstable and prone to oxidation; to preserve it from this as far as possible, it is rubbed up with sugar.

FERRI IODIDUM—IODIDE OF IRON, FeI_2, = 310.

PREPARATION.—By heating together iron wire with twice its weight of iodine, and eight times its weight of water, until the solution becomes colourless; it is then filtered and evaporated to solidity.

CHARACTERS.—A crystalline, green substance with a tinge of brown, containing about 18 per cent. water of crystallization and a little oxide of iron, without odour, deliquescent, soluble in equal parts of water, forming a greenish solution which very readily absorbs oxygen, and changes into free iodine and ferric peroxide. It is decomposed also by heat, emitting coloured vapours of iodine; the altered solution may, however, be restored by warming with more iodine and iron, and may be preserved in strength by keeping a piece of iron in it; so that as iodine is liberated, it can re-combine to iodide. Syrup will preserve to a great extent, and it is in the form of syrup that it is most frequently ordered (*v.* p. 616); it is incompatible with alkalies and their carbonates.

A Bromide of Iron is prepared similarly by direct combination, and is sometimes prescribed, but is not yet officinal.

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FERRI ARSENIAS—ARSENIATE OF IRON, $Fe_2As_2O_8 = 446$.

PREPARATION.—From a solution of sulphate by the addition of a mixed solution of arseniate, and of acetate of soda: the precipitate is filtered and dried at a low temperature to avoid oxidation. In this process, arseniate of iron, sulphate of soda, and free acetic acid are formed; without the acetate of soda, free sulphuric acid would be present, and this would dissolve the iron salt: the decomposition is complex.

CHARACTERS.—Arseniate of iron is an amorphous powder, white when first formed, but becoming grey or greenish-blue from absorption of oxygen: insoluble in water; soluble in hydrochloric acid. Thrown on live coals it evolves the garlic odour of arsenic, and is essentially an arsenical remedy, for the quantity of iron in any admissible dose is insignificant.

FERRI PHOSPHAS—PHOSPHATE OF IRON,
$Fe_2P_2O_8 = 358$.

PREPARATION.—By a process analogous to that for the arseniate; sulphate of iron is precipitated by phosphate of soda, some acetate of soda being also added to neutralize any free sulphuric acid that would be liberated from the iron salt. The precipitate is dried at low temperature to prevent oxidation.

CHARACTERS.—A slate-blue amorphous powder, almost tasteless, insoluble in water, soluble in acids.

Syrupus Ferri Phosphatis (*v.* p. 616).

Another group of iron compounds may be made of the *scaly* preparations, which are compounds of the metal and often of some other drug in addition, with a vegetable acid, such as tartaric or citric acid.

FERRUM TARTARATUM—TARTARATED IRON.

PREPARATION.—Freshly-precipitated peroxide of iron is dissolved in solution of acid tartrate of potash and allowed to

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stand for twenty-four hours, concentrated at a moderate temperature, and poured, when of syrupy consistence, on flat plates to solidify.

CHARACTERS.—Occurs in dark garnet-coloured scales; soluble in water, sparingly so in spirit. If boiled with potash or soda it deposits peroxide of iron, but is distinguished from the ammonio-citrate by not evolving ammonia under the same conditions, and also by leaving an alkaline ash.

FERRI ET AMMONIÆ CITRAS—CITRATE OF IRON AND AMMONIA.

PREPARATION.—By dissolving freshly-precipitated peroxide of iron in citric acid with heat, adding ammonia to neutralization, evaporating to consistence of syrup, and then drying in thin layers on plates.

CHARACTERS.—Occurs in transparent ruby-red scales, of sweet astringent taste and slightly acid reaction, soluble in water, almost insoluble in spirit. If boiled with soda or potash, it evolves ammonia, but alkaline carbonates do not readily decompose it, and it may, therefore, be given with them in effervescence with citric acid: the iron salt should be put into the acid solution.

FERRI ET QUINIÆ CITRAS—CITRATE OF IRON AND QUININE.

PREPARATION.—By dissolving freshly precipitated peroxide of iron and quinine in solution of citric acid, adding ammonia and evaporating to dryness at moderate temperature. The product is a triple citrate of iron, quinine, and ammonium, and contains both a ferrous and a ferric compound.

CHARACTERS AND TESTS.—Occurs in greenish-yellow scales which become darker by age; they are at first deliquescent and very soluble in cold water, but become less so on exposure to light; it has a chalybeate, and at the same time a bitter taste. It should contain 20 per cent. of Fe_2O_3, and 16 per cent. of quinia, but the proportion of the latter varies, falling sometimes to 4 per cent. The solution is slightly acid: soda

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precipitates the reddish-brown peroxide Fe_2O_3, and ammonia a white deposit of quinia.

The citrate of quinine with iron and zinc, and with iron and strychnia, and many other double compounds, have also been prepared in granular effervescent form.

ABSORPTION AND ELIMINATION.—If, in former times, the absorption of *any* medicine was commonly denied, with us the absorption of *all* is now commonly accepted as a necessary condition of their acting on the system, and yet the absorption of medicinal doses of iron has been doubted by some eminent men, and mainly because chemists, after giving the drug to animals, have often failed to detect an increased quantity of it in the vena portæ, and have sometimes failed to find any in the urine.

On appeal to the clinical evidence of improved colour and tone after the use of iron, the objectors attribute such results to a local tonic action upon the gastric mucous membrane leading to improved digestion; but besides that iron salts have often rather a contrary effect, it would not, in any case, account for all that we see, nor for the chemical changes produced in the blood. It seems more reasonable to allow that the medicine, which we can prove to be, to some extent, soluble in the gastric fluids, should be really absorbed, at least to the extent of its solubility. From most articles of diet certainly traces of iron are absorbed, as we know from detecting the metal in the blood and tissues: if there be some failure in the supply, or in its assimilation, then colour and strength fail (just as when iron is removed from a *soil*, *white* vegetables and *chlorotic* oats spring up from it), and conversely health and colour usually return when suitable ferric preparations are added to the nutriment or to the soil. Definite facts in proof of absorption are such as the following: Tiedemann and Gmelin administered to a horse about 6 dr. of sulphate of iron, and found an increased amount of the metal in blood from the splenic and hepatic veins, and in some experiments, in the lymph also. Manghini recorded a distinct increase in the amount of iron in the blood of dogs when he added the metal to their food (Bayle, Biblio. de Thérap., v. iv.). Wöhler, though he failed to detect iron in the urine

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after giving various preparations of it to animals, yet succeeded in detecting it by means of tincture of galls in the urine of patients taking chalybeate waters; he also noted its occasional presence in calculi and in urinary sediments. (Treviranus, Zeitschrift, vol. i., 1824, p. 302). Quevenne, in his careful and admirable memoir, says that only a minute quantity can be detected in normal urine, but that after medicinal doses the amount is increased slightly: in the bile and fæces the increase is greater (Bouchardat, Archives de Physiol., etc., No. 2, Oct., 1854). Schroff found that when small doses were given to animals, elimination by the kidneys was evident, and began sooner, and continued longer, than after larger doses; he recorded also the curious fact (and Becquerel corroborated him), that even during the use of equal and continued doses, the amount passed in the urine was subject to much fluctuation, implying that that secretion was not the best gauge of absorption. Bence Jones speaks of detecting iron in the urine within ten minutes of the administration of a soluble salt, also of the rapid diffusion of another portion of it into the textures and corpuscles (Lectures, Med. Times, ii., 1860, p. 245), and Délioux de Savignac affirms that it may be readily and frequently found in all the secretions (Gaz. Méd. de Paris, April 25, 1874). Bistrow verified the presence of nearly double the ordinary amount of iron in the milk of a goat after the administration of 15 to 40 gr. of lactate of iron; elimination of increased amount began in the milk forty-eight hours after giving the dose, implying a slow absorption or long detention in the tissues (Husemann). In Dr. Marcet's classical case of a man who had swallowed several knives, particles found in the bile were attracted by the magnet, and that liquid contained more than double the normal amount of iron (Philos. Trans., xii.).

More modern observations are those of Rabuteau, who passed through a tube varying amounts of protochloride of iron into the stomach of dogs, which were killed a few hours afterwards; the stomach was found to contain only a small amount of the compound, the intestine somewhat more, but the greater part had passed into the blood, which was found on analysis to contain, in these cases, distinctly more iron than under ordinary conditions (Journ. de Thérap., 1875). In another series

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of experiments he injected the same salt directly into a vein; it did not cause coagulation—on the contrary, it increased the fluidity of the blood, and yet no increased amount of iron was found in the urine. The greater part of what was injected passed away by the intestine, proving again that failure to find the metal in the urine is no proof of its non-absorption into the blood; similarly, the protoxide was injected in large doses by Papi, and was found unchanged in bile and fæces, but not at all in urine (Husemann).

I cannot doubt that a true absorption of iron-compounds occurs from the gastro-intestinal mucous membrane, though it may be often partial and incomplete, and is certainly rather slow and limited: it varies according to the preparation used, the reaction of gastric juices, and the state of the stomach as to food, etc. Woronichin showed that whilst chloride of sodium promoted the assimilation of iron, chloride of potassium much increased its elimination (Wiener Med. Woch., ii., 1868), and Brucke demonstrated in rabbits, that after a certain period the system, or more accurately the corpuscles, became so charged with the substance that it was no longer retained in the tissues, but passed almost wholly in the urine (Husemann).

With reference to the absorption of iron from the cellular tissue, C. Bernard performed a well-known experiment, injecting ferro-cyanide of potassium into the thigh of an animal, and solution of lactate of iron into its neck; the spot in the thigh remained unchanged in colour, but the neck quickly showed blue, implying that the cyanide had been taken into the circulation, and so reached the iron, but the lactate of iron had not travelled to the cyanide. Soluble salts, however, are certainly absorbed from wounds, and from the bared skin (Husemann), and recently, good effects have been obtained from hypodermic injection of a double salt (pyrophosphate and citrate) "in pernicious anæmia," after failure of ordinary means (Huguenin, Schmidt's Jahrb., Bd. clxxiii., 1877). The observations of Hamburger as to the absorptive powers of the vagina (tampons soaked in iron solution being introduced into it) were vitiated by his confining analyses to the urine—elimination by that secretion being, as we have seen, very uncertain—and he could come to no definite conclusion (Prager Vierteljahrschrift, 1876, p. 145).

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If doubts have been expressed as to the fact of iron absorption, there has been still more controversy as to the mode in which it is effected, and this, indeed, may differ according to the preparation employed. The finely-divided *metal*, "reduced iron," is first oxidized by the help of water (for if the compound contain any sulphur, disengaged hydrogen makes itself evident as a sulphuret in eructations). The *protoxide* and the *carbonate*, themselves not soluble enough for absorption, are rendered so by the hydrochloric acid of the gastric juice (as evidenced by experiments with the gastric juice of dogs); the *protochloride* does not coagulate albumen, and is readily absorbed. The *sesquioxide* becomes first perchloride and then protochloride, and is absorbed as such (Rabuteau).

It was formerly held that all proto-salts became quickly changed in the system into per-salts, because this change so readily occurs outside the body, but various conditions will prevent or even invert it. Thus, Quevenne notes that a natural protocarbonate remains as such in many mineral waters—that per-salts are reduced by alkaline tartrates, by charcoal, or simply by cold—and that the ethereal "tincture of steel" is rendered colourless and reduced to protochloride by mere exposure to the air and light. Stenhouse found the per-salts to be reduced by organic substances generally, and C. Bernard, after injecting a per-salt into the jugular vein, recovered only a proto-salt from the urine. In short, it is probable that if iron exists at all in the system as a per-salt it is only for a time, and under the temporary influence of an increased amount of oxygen; its rapid change from one condition of oxidation to another is possibly in accord with a general law of the organism (Quevenne).

Salts of the *organic acids*, the citrates, lactates, and tartrates, may be absorbed directly into the blood, the acid becoming quickly oxidized or "burnt off," and the metallic base left free to combine with the blood constituents. Rabuteau suggests that a carbonate of iron may be formed, as are carbonates of the alkalies after administration of alkaline citrates, etc.

The *potassio-tartrate* or tartarized iron has seemed to be more readily assimilated than any other preparation (Léras, Mialhe). The *iodide of iron* exhibits the properties of iodine rather than of the metal, and has proved more irritating than simple iron

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compounds. The whole of the iodine has been found eliminated in the urine after a few days, whilst but little of the iron has passed out (Quevenne, Melsens), proving that complete separation of the constituents occurs in the system.

Salts of the *mineral acids*—the chloride, nitrate, and sulphate—if given so diluted as not seriously to constringe the gastric membrane, nor to coagulate albumen, may be absorbed *directly* into the blood, and much more quickly than the metallic preparations; (Mialhe suggests that the blood-alkalies combine with, or neutralize, the acids so as to leave the metal free for oxidation or combination). Stronger solutions must, for their first effect, coagulate the albuminous material they meet with in the stomach. Mitscherlich found a "proto-albuminate" of iron in the stomach of rabbits; but, within certain limits, this compound is soluble both in excess of the iron solution, and in fresh quantities of albumen. Gubler, indeed, recommends it as a good form for administration, being both active and non-irritant. It has been generally held that this compound of iron was absorbed and circulated as a per-albuminate, but, according to Dietl, *proto-albuminates* are much more soluble than the per-salts (Schmidt's Jahrb., 1874); the same has been said of proto-chlorides, but practically both forms are available. The precipitates formed by *per-salts with albumen* are soluble under various conditions; using 1½ parts of ferric chloride to an albuminous solution, H. Rose found the precipitate dissolve in an excess of the salt, and when quite fresh, even the "blood-alkalies" dissolved it. When albumen came into contact with weak iron preparations a few drops of weak acid, or sometimes of alkali, were enough to help solution in the gastric juice (Dietl). As qualifying the observation of Lersch that albumen could supply the place of acids as a solvent for iron in the gastric juice, Dietl found that iron albuminate was soluble in soda solutions, that iron phospho-albuminate was soluble in contact with phosphate of soda, and that alkaline phosphates generally favoured the absorption of iron salts after they had become albuminates (Schmidt, loc. cit.).

It is probable that iron is not only absorbed as an albuminate, but eliminated mainly by membranes having albuminous secretions, such as mucous and serous membranes. Dr. Ringer refers to experiments in which, after being injected into the blood, most

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of the iron was detected on the mucous lining of the intestine, the bronchi, the gall and urinary bladder, and the serous membrane of pericardium, etc. Gubler relies on such facts to explain the astringent action of iron on various parts distant from the stomach, reasoning that the metal becomes separated by such secreting surfaces from the albumen with which it has been combined, and then recovers and exerts its natural astringency (cf. p. 293).

To resume: of the three groups of preparations—the first comprising the reduced metal and carbonate; the second, astringent acid soluble compounds; and the third, soluble non-astringent ones—*all* are susceptible of absorption under favourable conditions, the first comparatively slowly, the second (when diluted) quickly, and the third group to a medium extent. This fact becomes of importance in guiding our choice of a preparation in different maladies. Of either group a certain proportion, according to the dose, the condition of the stomach, etc., may remain unacted upon, and consequently unabsorbed, and pass into the intestine mechanically mingled with the food; at this stage some further proportion is absorbed under the influence of fats (Mialhe), or of alkaline secretions, or of bile. It has long been recognized that the bile contains a relatively large proportion of iron, and Lusanna argued that the greater part, if not all, of the administered metal passed only into the portal circulation from the mesenteric vein, and was eliminated by the bile. More recently the fact has been used as an argument to show that the effete blood-corpuscles are broken up in the liver, and furnish to the bile its large proportion; thus, Dr. Young, after many analyses, fixing ·0065 as the amount of iron contained in the 100 grammes of human bile, calculated it to represent 6·63 grammes of corpuscles (Journ. Anat. and Physiol., 1871). However it be, iron is largely eliminated in that secretion, but any amount that passes through the intestine is liable to be changed into tannate or sulphide, and so to colour blackish the fæcal mass; if this be of ordinary consistence, its external surface, which is alkaline, will be found more deeply stained than the inner part, which is slightly acid (Quevenne). In suckling children, the coloration will not occur, and if the salt be very completely absorbed, as are small doses of protochloride (Rabuteau), or of tartrate (Stillé), it will not be noticed

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for some days, or until the system is saturated. Again, if the iron pass without any assimilation, it is also said not to colour the stools, so that this effect has been considered, though I believe incorrectly, some guide to the absorption of the drug (Kraus, in Ranking, i., 1872, p. 272).

PHYSIOLOGICAL ACTION.—*External.*—Compounds of iron with the mineral acids act as caustics, irritants, or simple astringents, according to the kind and strength of preparation used; they are also, to some extent, antiseptic. A caustic, destructive action is exerted by the solid perchloride, especially upon raw surfaces or mucous membranes, but it is not so deep or thorough as that of the mineral acids alone, because of the rapid coagulation of albumen. The astringent effect of dilute preparations is explained partly by such coagulation, and partly by the constriction of capillaries induced.

Kulischer has made curious experiments to test the comparative effects of certain astringents and hæmostatics; having divided some blood-vessels in the limbs of frogs, he stayed the bleeding with different astringents applied for various lengths of time, and then injected liquid into the larger blood-vessels, and calculated the amount of force required to re-open those that had been divided and closed; from his results he concluded that of iron solutions a strength of 30 per cent. gave the best results, and the good effect was proportioned rather to such strength than to the duration of its application (Schmidt's Jahrb., Bd. clxix., 1876). Some researches by Rosenstirn upon the same subject, though conducted in a different manner, show also how much the action is dependent upon a definite strength of solution, and enable us to compare the effect of iron with that of other astringents. He examined and measured, under the microscope, the amount of contraction of blood-vessels in a frog's mesentery after application of 10 per cent. solutions of nitrate of silver, acetate of lead, and perchloride of iron, and the last acted not at all; he then used 50 per cent. solutions, and found the iron one very effective —it narrowed both veins and arteries at the place of application, arrested circulation, and acted as a true styptic on the blood itself; the adjacent vessels became dilated.

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The coagulum formed in the living vessel by perchloride of iron is soluble, to some extent, in the stream of alkaline blood, and especially so if the astringent solution used be unduly weak; it is also soluble in slightly acid liquids, but is rendered more consistent by combining the iron with alkaline chlorides (Piazza, Bull. de Thérap., 1868). The blood-clot, with lactate of iron, is said to form more slowly, and to be more permanent.

The antiseptic powers of astringent iron preparations are connected with the coagulation of albumen, and strong solutions are fatal to the lower forms of vegetable life. Ferreil ascertained that the neutral strong solution of perchloride arrested decomposition in a blood-clot (when it had commenced), and formed with fresh blood a coagulum that remained unaltered for many months (Union Méd., 1859, p. 374). Similar observations have been repeated since, but the irritant properties of the strong iron chloride preparations make them less suitable for surgical disinfectant purposes than they would otherwise be, and carbolates, sulphates, etc., have superseded them.

PHYSIOLOGICAL ACTION.—*Internal.*—Circulatory System.—Under the ordinary use of neutral preparations of the drug, the pulse becomes more full and forcible, and the colour of face and mucous membranes more florid. It is commonly said that if they be pressed beyond a certain point, symptoms of plethora and of congestion set in, as shown by flushes and giddiness, engorged viscera, and tendency to hæmorrhage; but if the patient have good air and exercise, and moderate food, such effects are not likely to occur. The blood will not take up more than a certain amount, and will protect itself by non-absorption, rather than by elimination. Hirtz even asserts that he has never seen congestive symptoms, vertigo, etc., except from the excessive use of chalybeate waters containing carbonic acid, to which he attributed them (Nouveau Dict.).

According to Sasse and Pokrowsky, the use of iron salts increases the heart-action, and Laschkewitsch proved increased blood-pressure in animals taking even small doses (Husemann). In illustration of the effect of large doses (though complicated by alcohol), may be quoted the case of a woman who swallowed 1 oz. of the tincture of perchloride, during an excited condition;

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the pulse became quick and small, the eyes injected, and the face flushed; convulsive attacks occurred, but were probably hysterical; she recovered after free vomiting (Warburton, Lancet, i., 1869). In disease, on the other hand, there is evidence sometimes of a sedative effect on the circulation. Giacomini records a slow and feeble pulse, pallor, etc., after 20 to 40 gr. of carbonate; and Pize found it lower the pulse and quiet the circulation in purpura and chlorosis, when accompanied with palpitation; in the former case, some gastric irritation was probably caused; in the latter, good effects resulted probably from improved blood-condition. I have known the acetate quiet the circulation when the perchloride did not do so.

Action on Blood.—According to Nasse, there exists in 1,000 parts of blood, 0·832 of iron oxide. Hæmoglobin contains 0·42 per cent. as a constant quantity; most of it is in direct organic union with the red corpuscles, in the proportion of about 1 part of iron to every 230 (Gorup Besanez); when dried, they contain seven times as much as the fibrine, and four times as much as the serum (Boussingault). Being required then for the normal constitution of red blood, iron is essentially a *food*, but since illness follows deficiency in the number or quantity of corpuscles, and iron in substance will often remedy such illness, it equally comes within our province as a *medicine*, and from its curative effects, we may, inverting the general rule, deduce some part of its physiological action. That it can increase the number of red corpuscles is shown by the observations, *e.g.*, of Rabuteau, who counted them by Malassez's method, in a case of chlorosis before and after twenty days' treatment by protochloride of iron, he found the number in a cubic millimetre to be nearly doubled (Gaz. des Hôp., Jan., 1875), and in a specimen analysed by Prof. Simon, the globulin and hæmatin were more than trebled (Animal Chemistry, Syd. Soc.). I need not multiply examples of this fact (though it has been denied), but there is something further to be learnt from the recent and careful observations of Hayem, on the blood of anæmic persons (Comptes Rendues, 1876, p. 985). He found that in cases of moderate chlorosis, the *number* of corpuscles was not markedly less than normal, but they were altered in shape and size, apparently in consistence, but most

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markedly in *colour-power*, so that a given quantity showed a red tint not deeper than that of half the number of normal corpuscles. Further, after a course of iron, the number of corpuscles in the same patient was not always increased, sometimes it was diminished, but then the corpuscles individually had grown larger and of normal shape, and of so good a colour as to equal even a greater number of the ordinary kind; he concludes then that iron acts by improving the internal nutrition of the globules, "it solicits them" to take up more hæmatin, more colouring matter. These observations confirm the older ones of Le Canu (Thèse, 1847), that iron is the main constituent of hæmatin, is inseparable from the colouring matter, and must be at least an important element in the colour itself. Hayem's conclusions are of still more importance as bearing on the assertions of Denis and of C. Bernard, that there is no real deficiency of iron in chlorotic blood, because they prove such a definite change in its *vital* characters under the medicinal use of the drug. Granted that there is no numerical, there is clearly a physical or a vital change produced by iron; and although it may be true that ordinary nutriment contains as much iron as should be wanted (Bernard), yet it seems equally true that we may sometimes have to give much that we may get a little absorbed (Gubler), that we must therefore give it "en masse," as we do, and (apart from all theory) Hayem furnishes us with a rational basis for our therapeusis. That the proportion of iron can vary in blood is proved by the analyses of Picard (Comptes Rendues, Nov., 1874); in 100 cub. centim. taken from three dogs respectively young, adult, and weakened by hæmorrhage, he found that the amount of iron was ·092, ·065, and ·041, and he established also the fact of a definite and constant relation between the amount of iron in any specimen of blood, and the amount of contained oxygen as liberated in vacuo from quantities of 100 cub. centim.

If it be asked *how* iron adds itself to the corpuscles and promotes their growth, we must recognize that it is not by mechanical addition to the formed corpuscle, or else the proportion in chlorotic blood could be at once increased, and failure to cure would not occur, nor relapse be so frequent. An observation by Quevenne throws some light upon the process; he found in

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proteid solutions withdrawn from the stomach of dogs more abundant precipitates of nutrient material if meat or wine, or iron especially had formed part of a meal, and suggested that in the portal vein a similar precipitate occurs (from the meeting of currents from splenic and mesenteric vessels both laden with the results of digestion in intimate contact with the added iron) that such precipitate is at least precursory to the formation of globules, and that at this stage iron exerts its blood-forming power (Mémoire, etc.). It would seem that better corpuscles are formed when (the vital processes being fairly active) one of their essential constituents is presented in unusual abundance for absorption. It becomes then combined with them in some organic, rather than chemical or mechanical union; and besides such direct action in the formation of globules, iron exerts special stimulating power over the blood-glands, which power, indeed, is by Trousseau and others considered more important than the last-mentioned. Further, when even a few new corpuscles have been formed, they add fresh nerve-energy and improve digestion, and the blood-forming process becomes still more actively assisted. Iron has been variously thought to be in the corpuscles in its metallic state, as phosphorus exists in the brain (Le Canu, Mulder), or as a free phosphate (Fourcroy), or as a peroxide (Denis, Mialhe, and a majority of observers). A precise chemical theory was elaborated by Liebig, who taught its presence as peroxide on account of its reactions with sulphuric acid, and found that this hydrated peroxide, in contact with moist organic membrane in partly closed vessels, could change to a protocarbonate, and on free exposure to oxygen could change back again, with evolution of carbonic acid: so that venous blood was held to contain a protocarbonate, and recently aerated blood a peroxide. It is difficult to accept so entirely chemical a theory, which implies that the element is more loosely combined with the corpuscle,—more distinct from its substance,—than it can be; other difficulties are stated in physiological works, and Liebig's view, though highly ingenious, and containing no doubt a partial truth, can only be accepted as an hypothesis.

Oxidizing Power.—To the metallic element in the corpuscles has been somewhat fancifully attributed an electrical and a

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polarizing action, and even a power of increasing heat by mechanical friction! There is a general and better-founded opinion that it greatly aids in the conveyance of oxygen and in oxidation (a main function of the corpuscles), and some modern researches support this opinion,—thus, Schönbein, quoted by Dr. A. Sasse, proved that animals without blood-corpuscles were suffocated in oxygen as much as others in nitrogen; that the gas must become changed into ozone and antozone in order to be fully efficient, and that iron, or corpuscles, will effect this change. Iodized paper is turned blue both by ferric solutions and by diluted blood, and peroxide of iron can change into protoxide and ozone. As an illustration, he quotes the spread of rust on steel, or "iron mould" on linen, the stain extending by formation of ozone, which corrodes the adjacent particles of the steel, whilst the reduced oxide attracts fresh oxygen from the air. Similarly, it is argued, the iron in the corpuscle continues alternately to attract and to give up oxygen, and to become a proto- or a per-salt until finally excreted (Schmidt's Jahrb., v., 1865).

If iron, when taken into the system, does aid oxidation it should raise the *temperature* and increase tissue-change, but the amount of scientific evidence on the subject is unfortunately small. The observations of W. Pokrowsky, though valuable and often quoted, were made on patients seriously ill and recently removed to hospitals, and seem scarcely sufficient for the conclusions drawn from them. In five out of six cases the temperature was slightly raised; in one (a case of phthisis with hæmoptysis, taking small doses of tinctura ferri) it was lowered; the pulse was either unchanged or slightly increased, the elimination of urea was augmented, and weight was gained. In one case the rise of temperature followed within five hours of the dose, and it occurred equally in the cases where temperature was previously normal. It should be noted that the syrup of iodide of iron was chiefly used, and the iodine must be allowed for as influencing tissue-change; also that Pokrowsky himself, whilst recording improved nutrition, traces it only to "improved tone of capillary vessels," not to increased oxidation (Virchow's Archiv, Bd. xxii., v. 6); he states that he acted as a student under Dr. Botkin. I find no reference to other

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observations by the latter upon healthy men, as mentioned by Sasse.

Some recent analyses by Rabuteau would seem to support the supposition of increased oxidation, but they refer only to the renal secretion; comparing the results of five days when taking daily 12 centigrammes of perchloride of iron with the same period, on the same diet, but without the iron, he concluded that it did not affect the quantity of his urine, but augmented its acidity and its solid constituents and urea (10 per cent.). Phosphoric acid was lessened, as it usually is, under cod-oil and other restoratives.

The researches of Picard (*v.* p. 569) proving a definite ratio between the amount of iron and of oxygen contained in the blood, are of importance in this connection, and it is an axiom that iron preparations exert their best curative effect when the supply of oxygen is ample; but the conclusion of Sasse—that iron can supply the place of red corpuscles as an ozonizing agent in the body can scarcely be correct; were it so, the cure of anæmia and chlorosis would be more certain than it is. We can but consider iron as an adjuvant, and as being, when in the corpuscles, subject to other than merely chemical laws.

Different Action of Proto- and Per-salts. — The important experiments of Blake, so far as they can be practically applied, would point to a marked difference between the action of proto- and per-salts on the blood and the circulation. Injecting 10 gr. of protosulphate (in solution) into the jugular vein of a dog, there occurred a quick but temporary depression of the heart-action and blood-pressure; with 28 gr. heart-action stopped, and pressure fell to zero; 70 gr., in divided doses, caused a gradual general dulness, and death from asthenia—the right cavities of the heart were distended with dark blood, the left contained 1 oz. of brighter colour, but the coagulating power was lost.

When 2 gr. of persulphate, dissolved in 2 oz. of water, were injected into the same vessel, pressure was diminished for a brief time, but quickly rose again when 3 gr. more were given; death soon followed; the left heart-cavities were empty and contracted, the right distended, the blood coagulated at once when exposed; the lungs were bright scarlet and contracted, and Dr. Blake attributed death to contraction of their capillaries preventing the supply of arterial blood to the left heart. Five grains

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thrown into the axillary artery raised the blood-pressure at once from 6 to 12 degrees (by the hæmadynamometer); death followed, and both sides of the heart contained dark blood, implying that the lung-contraction was overcome in this instance, but only by an extreme degree of pressure. The obstruction of the lung-capillaries might be caused by a physical change in the blood, rather than by contraction of the vessels, but the quantity seems too small for the former effect, and an analogous contraction of vessels is produced by digitalis, which proves its possibility.

The general results of the experiments go to demonstrate that *proto-salts* lower cardiac irritability, and in toxic doses arrest heart-action, cause slow respiration, sedation of nerve-system, and death by depression: *per-salts*, on the other hand, have no direct action on the heart, certainly do not lessen its irritability; they cause symptoms of pressure on the nerve-centres, and death through interference with the pulmonary circulation, cutting off the supply to the left heart. Collaterally, it is argued that proto-salts cannot be readily oxidized in the blood, or else some "peroxide-effects" would be developed from 70 gr. of a proto-salt; and that per-salts are not readily reduced, or the effects of such small quantities would not be so persistent (Journal of Anatomy and Physiology, 1869), but reviewing all the experiments and conclusions, we must doubt whether the mechanical forcing of substances into the blood-current can be held to compare with natural absorption and assimilation. The difference, however, exerted by the two classes of salts upon coagulation, has an important bearing upon their use for local injections, on the formation and solution of clot, on embolism, etc.

Digestive System.—Most of the soluble salts of iron have an inky astringent taste, and by continued use, stain the teeth and mouth of a dark colour (tannate of iron). Compounds with a mineral acid exert a local astringent action on the mouth and stomach, and if the dose be small and diluted, may improve the tone and the functional power of the gastric membrane: but these, or any other preparation, if given in undue quantity, may irritate, and cause indigestion (from lessened secretion), with sense of weight, nausea, or diarrhœa.

Quevenne experimented with gastric fluid withdrawn through a fistula from the stomach of dogs, and judged of the effects of

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iron on digestion by the precipitates of peptones obtained from the fluid at certain periods after a meal. There was less precipitate when the juice was acid than when partly neutralized, but he concluded that various forms of iron, given with food, improved the character and amount of the precipitate: they did not increase the proportion of pepsine, nor alter the duration of the digestive process, but were quite readily absorbed, and the dogs thrived and gained flesh under their use. On the other hand, when given without food, and especially in the metallic form, iron did not stimulate the formation of sufficient secretion to dissolve itself, but acted as a foreign body, and impaired digestion: 10 to 20 gr. of reduced iron would cause diarrhœa, hence a reason for the ordinary rule of ordering iron preparations at the time of a meal, and in small doses (2 to 3 gr.). The sulphate and chloride of iron have sometimes, by mistake or for criminal purposes, been taken in large quantities (1 oz. and upwards), and have caused violent pain and vomiting, with other symptoms of irritant poisoning, and gastro-enteritis, but have rarely proved fatal (Taylor).

Secretion.—Astringent preparations will usually lessen the secretions, especially those of the gastro-intestinal tract. Upon the kidney, in health, the effect as to quantity of secretion is not much, but some irritation of the bladder and the urinary tract may lead to increased frequency of micturition. In some persons, however, and in some diseases, iron preparations, especially the tincture of the chloride, the citrate, and the tartrate, have proved good diuretics, directly or indirectly: the tincture, in fact, is termed by Simpson a "renal purgative" when recommending it in "surgical fever" (Med. Times, i., 1859, p. 517). The secretion of milk has diminished or ceased in cows drinking a ferruginous water, and in some suckling women taking a course of iron (Martin); Bistrow records a similar result in a goat under the use of lactate of iron: on the other hand, there is clinical evidence that non-astringent preparations taken by anæmic women during lactation will improve the secretion as well as the general health (Routh, Med. Times, i., 1859). The effect is clearly that of a restorative, and as we find so often in the use of iron, it will vary with the preparation and the patient taking it.

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Generative System.—From an early period iron has had the repute of specially stimulating this system. A classical cure of impotence by iron-rust amongst the Argonauts is commonly quoted, and we may rescue from oblivion the curious marriage-contract said to be common at one time amongst the burghers of Frankfort, to the effect that their wives should not visit the iron springs of Schwalbach more than twice in their lives, for fear of being too fruitful (Dr. Jacques, Thèse, Paris, 1843). There is clinical evidence of its value in sexual debility, and in derangement or suppression of the ovarian function, but it seems more explicable by a general tonic and hæmatinic power than by a special local action, though Trousseau attributes to iron aphrodisiac power. The tincture of the chloride is in somewhat common use as a supposed abortifacient. Taylor regards it as a dangerous drug for pregnant women, but his examples scarcely corroborate this, and the clinical evidence and experience as to medicinal doses mentioned later on (*v.* p. 607) tend to an opposite conclusion. We may recognize, however, that very large doses of astringent preparations are not safe—they may injure by general irritation or local congestion, as shown in some cases reported in Med. Times, ii., 1860, p. 84.

Synergists.—Manganese, and most tonics and acids: as astringent, ergot, turpentine, etc.

Antagonists — Incompatibles. — Weakening and fluidifying agents such as alkalies and mercurials: the former are also, together with sulphur and tannin, chemically incompatible with most iron preparations. Gubler mentions nicotine as antagonistic.

Therapeutical Action.—*External and Internal.*—In this instance I find it undesirable to separate the external from the internal application of the remedy, for they are very closely connected, and if one set of observers prefer the one in any particular form of disease, parallel observations will be found in favour of the other; thus it is as regards hæmorrhage, diphtheria, erysipelas, and even varix.

Iron in the metallic form was in early use as an astringent and roborant, though we note the absence of any mention of it in

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Hippocrates. In extraordinary demand at the early part of the last century, as a secret remedy, and under the name of "Elixir d'Or," "Gouttes d'Or," "Teinture de Bestuchef," etc., the perchloride solution with ether was priced at a golden louis per ½ oz., procured pensions and promotions for its makers, and served as a present for sovereigns; but when its last patentee revealed the secret, "for fear his death should lose it to the world," and when Catherine of Russia purchased the precious recipe for many thousand roubles, and presenting it to the St. Petersburgh College of Medicine allowed it to be published (1780), this remedy which had been held to cure "gout and epilepsy, cramps and paralysis, rheumatism and hypochondriasis," sank into an obscurity as little deserved as was its previous reputation. Bayle, whose treatise is an excellent epitome of the therapeutical knowledge of his time, mentions only the metal and the carbonate as remedies in neuralgia and chlorosis (Biblio. de Thérap., iv., 1837), and the use of soluble ferric compounds—a use so frequent and so valuable in modern practice that we may wonder how our predecessors fared without it—dates really from about 1850.

Hæmorrhage.—The astringent compounds of iron with a mineral acid are excellent local styptics in all forms of capillary hæmorrhage, such as from leech-bites, wounded gums, hæmorrhoids, bleeding from the nose, etc. The part should be thoroughly cleansed from clot, and then a plug or compress moistened with the solution should be firmly pressed upon it, or in cavities an injection (diluted) may suffice. Sir James Simpson strongly commended a solution of the perchloride in glycerine, used it freely for all forms of hæmorrhage, and with special success in some severe cases of bleeding from the vagina and uterus (Med. Times, i., 1858, p. 79). Demarquay, Lallemand, and Deleau were using the same hæmostatic with great advantage in France about the same time (Gaz. des Hôp., 1858–59).

The liquor ferri perchloridi fortior B.P. is quite serviceable for the purpose, but is more acid, and proves often more irritating than need be, and may be well diluted with an equal part of water or glycerine. The liquor ferri sulphatis is preferred by many surgeons, and by others the liquor ferri

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subsulphatis, or Monsel's solution[1] of the American Pharmacopœia; this is made with sulphate of iron, sulphuric and nitric acids, and is much less caustic and irritant than our solution; it is used in rectal hæmorrhage—1 part to 4 of water (Allingham, Lancet, i., 1874)—and the "hæmostatic cotton" used by Marion Sims is prepared with it. The so-called "iron alum" is probably an equally effective preparation.

Tonsillar Hæmorrhage—Wounds.—Wetherby, of New York, records a very severe case of bleeding from the tonsil (cases which are specially anxious ones, on account of the proximity of the carotid) completely controlled by the application of Monsel's solution (Ranking, ii., 1866); and I have seen instances in which a large vessel must have been wounded by an incision in the tonsil, effectively treated by the local use of tincture of the perchloride; it should always be tried before more serious measures are commenced. As styptic applications to the bleeding surfaces of wounds, iron compounds are not so suitable as some others, because they necessarily prevent union by "the first intention," and they leave a coagulum, on the separation of which hæmorrhage is apt to recur. Maisonneuve, however, performed some of his boldest and most brilliant operations with their help; thus, he removed a growth occupying half the face and head, and involving numerous vessels, applying perchloride on pledgets of charpie at almost every stroke of the knife, and so that the weakened boy lost but little blood; a brown eschar formed, and separated about the twentieth day (Med.-Chir. Rev., ii., 1856). Bourgade applied perchloride to the bleeding surface immediately after all operations—calculating to render them by this means "as painless and as safe as if caustic had been used instead of the knife"—and to prevent septicæmia; the application was painful for a few hours, but not much pus formed, and granulation occurred in a healthy manner. He reports ninety-five cases (Union Méd., 1867, No. 104). The perchloride is still thus used sometimes in operating upon soft tissues in anæmic subjects when hæmorrhage is likely to be serious. I have seen it applied in the removal of a cancerous

[1] The original Monsel's solution was made with persulphate, as described by him (Recueil des Memoires, t. xvii., 1856, quoted by Buisson).

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tongue and of a cancerous breast, and also in a thigh-amputation, and in each case secondary hæmorrhage occurred, and I was not at all satisfied with the action of the styptic; further, it is not free from risk of causing embolism.

Hæmoptysis.—In various forms of hæmoptysis, phthisical and otherwise, preparations of iron are useful if active febrile reaction is not present. For internal use I prefer the acetate, or sometimes the sulphate, to other preparations, and they are especially indicated in the passive hæmorrhage of anæmic weakly subjects (of the acetate, I give the tincture in 5 to 20-min. doses every half-hour to two hours). Caution is needed as to their internal use in phthisis (*v.* p. 608), but their local use in spray or powder is advisable whenever the loss is severe or alarming. A striking case, in which death seemed imminent, and in which the insufflation of powdered sulphate at once and permanently controlled the bleeding, is given by Wetherby (Ranking, ii., 1866). Brondgeest (Brussels) treated successfully three phthisical cases by an atomized spray containing the chloride (Bull. de Thérap., 1866, t. lxxii.), and Cornil has related similar results.

I have treated several severe cases with satisfactory results by an "iron spray" containing either ¼ part of liquor ferri perchloridi, or 1 to 2 gr. of sulphate in the ounce of glycerine and water. It might be thought that blood thus coagulated *in situ* would increase a tendency to lung-congestion or chronic pneumonic phthisis, but practically I have not found it do so.

Epistaxis.—When this occurs frequently in patients already anæmic, or when the amount of blood lost threatens to bring on anæmia, iron will be found of great value, and especially in the form of acetate or perchloride: it should be commenced as soon as possible, while the hæmorrhage is going on, and continued for some time after it ceases. I have seen this treatment useful in the severe epistaxis of habitual drunkards; it is not, however, always safe for epistaxis occurring in the old, or those disposed to apoplexy.

Hæmatemesis.—I have frequently treated this form of hæmorrhage successfully by means of the perchloride of iron given internally; it has a direct local styptic effect, and in some aggravated cases, when the hæmorrhage has occurred frequently,

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it has arrested it at the time, apparently prevented relapse, and certainly lessened after ill-effects, such as anæmia. In recent acute cases, ipecacuanha powder in doses of 1 or 2 gr. is more efficacious, but in semi-acute cases it is well to alternate this remedy (every half-hour to every two or three hours) with 15 to 30 min. of the iron tincture in water. I have known this method check severe hæmorrhage in a case of gastric ulceration, after other remedies had failed, and Mr. Bowles records similar instances: he used 1 dr. of the tincture in 1 oz. of water, giving it after the stomach had been emptied by emesis, so that it could directly reach the bleeding part (B. M. J., i., 1872). Deleau, Pleischl, and others have also recorded excellent results from this treatment (Med. Times, i., 1857, Med.-Chir. Rev., 1859), and it might with advantage be more generally adopted. Iron alum (a double sulphate of iron and ammonia) is also very valuable in this and other forms of internal hæmorrhage (Lancet, i., 1871, p. 806).

Intestinal Hæmorrhage.—Perchloride is often useful in hæmorrhage from the bowel, and I have known it answer well. Several cases, somewhat obscure in character, but recovering under perchloride, are given in Bull. de Thérap., 1877. The ordinary cause of such hæmorrhage would be either cirrhosis of the liver or ulceration, and I do not think iron suitable for the former condition, but in the latter it is more indicated, since we know that it relieves hæmorrhage from gastric ulcer. In the diarrhœa and hæmorrhage of enteric fever, benefit has commonly been derived from its use. Dr. Russell Reynolds has used the perchloride (Med. Times, i., 1867, p. 32), and Dr. Broadbent the sulphate in enteric fever (B. M. J., ii., 1869), but I have not met with any published conclusions as to the value of these remedies. "Iron alum" I should myself prefer as a styptic in such cases.

Hæmaturia.—The internal administration of perchloride of iron is not desirable in acute renal congestion, but I have occasionally met with chronic recurrent hæmorrhage, apparently from the kidney, the subjects of which were anæmic and suffering from chilliness, nausea, faintness, etc., and who received much benefit from the perchloride. The dose should be from 15 to 30 min. every six hours, and its efficacy may often be

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increased by 2-gr. doses of ipecacuanha powder, given midway between. A very successful case illustrative of treatment by perchloride is reported by Vigla (Gaz. des Hôp., 1858). In urethral and vesical bleeding the same treatment is very serviceable, and in the latter malady iron injections into the bladder have been employed with advantage, but the solution must be weak, for if rapid and solid coagulation of blood within the viscus were produced, the effects might be worse than those of the hæmorrhage itself.

Purpura—Scorbutus.—Iron has sometimes succeeded well in purpura of passive character, but is not of much advantage in the bleeding of true scorbutus. Both the sulphate and the perchloride have cured cases when other remedies, such as sulphuric acid and change of diet, have had no effect. Homolle was the first physician to recommend the sulphate (Union Méd., No. 135, 1856), and Dauvergne, recording a striking instance of benefit from the perchloride, remarks that it acts better in cases with large effusion (in plaques) than in the merely petechial forms, and this I believe from my own experience to be correct (Bull. de Thérap., 1867). Other cases may be found in Bulletin, 1868, Brit. For. Rev., i., 1861, and Med. Times, ii., 1861, p. 501; they include one patient at seventy, and one a child; in one, the malady was connected with deficient supply of animal food; the *arseniate* answered well in another case (Lancet, ii., 1872).

Uterine Hæmorrhage.—All cases of uterine hæmorrhage must be carefully considered from every point of view, before resorting to medicinal or local styptic treatment. In a large number of such cases iron is highly useful, but it must not prevent the proper manual and surgical management of, for instance, retained placenta or fibroid growth, nor the depletive treatment of a congested uterus. In menorrhagia occurring in the young or the delicate, and accompanied with a generally lax anæmic condition, and often with intercurrent leucorrhœa, the sulphate or perchloride are suitable as internal medicines; the former, with sulphate of magnesia, is especially good. The excessive loss, as well as other and general symptoms which often occur at the climacteric period, may be also relieved by these remedies.

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Uterine Cancer, etc.—Simpson knew the value of perchloride in relieving the hæmorrhage and discharge of cancer, and French surgeons equally proved it. The liq. ferri fort. is exceedingly serviceable, as shown in a good paper by Dr. Gibb, of Newcastle; he either filled the vagina with a dilute solution for a few minutes, or plugged with tampons, or painted the strong liquor on the affected part, and so far relieved bleeding and pain, and improved the local condition, as to give, at least, a period of comfort (Lancet, ii., 1874, p. 830). I have myself used the same application with excellent results, and my colleague Dr. Potter, constantly uses in cancerous cases a plug of lint or cotton wool soaked in a solution of liquor ferri perchlor. fortior and glycerine (equal parts), and firmly pressed against the uterine surface, the vagina being filled with wool soaked in glycerine. Another method is to apply the saturated solution of perchloride to the affected surface on a Playfair's uterine probe wrapped with cotton wool; this is best in cases when the vagina will not tolerate the presence of tampons.

In cancer other than uterine its application is also valued by myself and many observers independently of its power as a hæmostatic: it constringes and modifies the affected surfaces, inducing a less rapid growth. Iron cannot cure cancer, but the debility and the anæmia dependent upon it may be much relieved by a course of it.

Villous Growth.—A severe and obstinate menorrhagia, dependent on this cause, was successfully treated by Breslau with an intra-uterine injection of equal parts of liquor ferri (Bavarian) and water; it was made through a catheter, left only one minute and then withdrawn (1858). This was one of the earliest cases of the kind, and illustrates a method which I have several times employed with advantage; but a more modern and often curative practice is to scrape the surface of the lining membrane with a curette.

Fibroid Tumour.—If the patient is suffering from marked anæmia and from continued loss when she first applies for advice, considerable relief to the symptom may be given for a time by the internal administration of the perchloride, especially when combined with ergot; it may possibly be required as a styptic to the cut surface after incision of the cervix; in

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cases of emergency, plugging of the vagina with saturated tampons is a valuable temporary resource.

Puerperal Hæmorrhage.—The local application of so excellent a remedy has not been neglected in this—perhaps the most anxious form of hæmorrhage with which we have to deal. Sometimes the use of plugs or tampons steeped in the solution, and packed in the vagina, has seemed the best mode of treatment, but it is not free from risk, for it may only conceal serious internal hæmorrhage, and moreover, the prolonged contact of strong preparations, even though at the time painless, has been followed by serious loss of substance, and permanent contraction and cicatrix (Gaz. des Hôp., 1869, No. 113). In post-partum hæmorrhage, the rapid application of a saturated sponge to the interior of a non-contracting uterus has proved efficient (Barnes), but the contact of a strong solution so quickly corrugates the membrane of the vagina and the os uteri, as to cause difficulty in carrying the instrument far enough, or in withdrawing it (Braxton Hicks, Norris).

Intra-uterine Injections.—Few surgical procedures have more widely and earnestly engaged professional attention of late years than the intra-uterine injection of strong ferric solutions. Schreier, of Hamburg, was accustomed to use weak injections (½ to 1 dr. in 4 oz. water) for hæmorrhage, either before or after delivery (Med. Times, ii., 1855), and still weaker injections (1 dr. to the pint) have long been practised in the Vienna school, if cold and ergot failed. Ford recorded the successful arrest of severe hæmorrhage after abortion by intra-uterine injection of ferric sulphate (1 dr. in 4 oz. water), also three other cases (Amer. Journ., April, 1868). Probably other instances might be found, but general interest in the subject was first thoroughly aroused by Dr. Barnes. The mode adopted by him was to mix ½ pint of the liq. ferri perchlor. fort. B.P. with water up to 1 quart, and to inject this slowly through a Higginson's syringe, of which the delivery pipe was passed well to the fundus uteri; by this plan he was satisfied that life had been saved several times, and he held it specially applicable to cases when contractile power could not be roused, and the uterus remained dilated and inert after a prolonged labour. The styptic mechanically stayed the hæmorrhage by sealing the

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vessels, and usually induced also uterine contraction (Med. Times, i., 1865; also Lancet, i., 1869, and B. M. J., ii., 1873). Dr. Hugh Norris (Somerset) recorded a similar experience about the same time (B. M. J., 1869–70). Cases for and against were soon reported from different parts of the country, and it was not long before a vehement controversy arose, tinged, unfortunately, with some personal animus. A case of secondary hæmorrhage really dependent upon retained placenta, but in which several injections of perchloride solution (the last one being of the strong and undiluted tincture) had been practised, died ultimately of septicæmia, and furnished the text for a full discussion at the Obstetrical Society. Such a case was not really illustrative of Dr. Barnes' mode of treatment, and although it proved fatal, the opinion of practical and experienced accoucheurs such as Braxton Hicks, Playfair, Potter, Edis, Murray, etc., was expressed decidedly in favour of such injections in suitable cases (Lancet, i., 1873, pp. 306, 407). On the other hand, Graily Hewitt, Routh, Bantock, and Snow Beck, referred to other instances in which such injections did apparently cause septicæmia and embolism. In Dublin, the favourable experience of Dr. Barnes was amply corroborated by Dr. Lombe Athill, whilst Dr. E. Kennedy took a much more cautious view, and urged the reservation of the method for a *dernier ressort* (Dub. Journ. Med. Sci., May, 1874).

In Edinburgh, the discussion of an unsuccessful case showed a balance of opinion against the procedure. Dr. Matthews Duncan especially questioned its propriety, though Dr. Alexander Simpson expressed a more favourable view (Edin. Med. Journ., Feb., 1875). In France, if we may judge by the observations of M. Budin, of the Maternité, professional opinion is decidedly adverse (Bull. de Thérap., 1876, p. 89). In Germany ferric injections seem to have been scarcely tried, for no account of them is to be found in the Archiv, Zeitschrift, Centralblatt für Gynæcologie, nor any comments on German cases in Schmidt or Virchow and Hersch Jahrsbericht.

An impartial estimate of English writings on the subject leads to the conclusion that the greater part of the favourable testimony comes from those who have really used the method of Dr. Barnes, whilst objections are made chiefly by those who

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have not ventured to try it. The latter urge (1) that the proper object in the treatment of post-partum hæmorrhage is to secure uterine contraction (not simply a plugging of the vessels with clot), and that cold, friction, etc., are better and safer agents for the purpose; (2) that there is too great tendency to neglect these measures for the more energetic iron treatment; and (3), which is most important, that such treatment exposes the patient to grave risk from the formation of emboli or the injection of air into veins, or the forcing of fluid through the Fallopian tubes. The first objection as to uterine contraction is met by the statement that highly-experienced men have, in some instances, failed to secure uterine contraction by any ordinary means, and have succeeded with the ferric injection, and have thus stayed severe hæmorrhage, and probably saved life, without any ill-result; but much weight must be allowed to the other objections. It is within my own experience that iron injections have sometimes been employed far too soon, from over-anxiety to stay what I should consider not excessive hæmorrhage, and which would have yielded, I believe, to cold and the judicious use of ergot. I am also cognizant of at least five cases in which death has followed apparently from embolism, and yet I do not blame the principle of the treatment so much as some defect in carrying it out. Thus, sometimes the uterus has not been properly emptied of clot beforehand; sometimes the solution has not been strong enough, and at other times the exit has not been free. The greatest care is required as to all these points. The patient should be on her back, the womb emptied of clot and gently compressed, the uterine tube should be long enough (about 9 in.) to reach to the fundus, the solution should be of about 2 oz. dry perchloride to 12 oz. water, or 2 oz. liquor ferri perchloridi fort. to 10 oz. water, free from air, and injected slowly and steadily, and the os must be patulous, and the exit quite free, so that no undue pressure or distension should force fluid into vessels or through the Fallopian tubes. If these precautions be all adopted, I believe the ferric injections may be used with safety and with the best results, even in most serious cases; they are an important addition to our means of saving life, but of late years the injection of *hot* water into the uterus has been found to be as efficacious as solution of iron and

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devoid of its dangers, and promises to entirely replace it in practice.

Injections in Aneurism, etc.—In 1852 Pravaz, of Lyons, excited the utmost interest by his discovery of the coagulating powers of ferric perchloride, its effects when injected into the vessels of animals, and its successful use in various forms of aneurism. His observations were confirmed and extended by Giraldés, Broca, and others, who formulated rules for securing a good and firm clot, and obviating the dangers of inflammation and embolism which were soon found to be involved. The greatest importance was attached to the purity and neutrality of the preparation, its due density and proportioned amount to the size of the aneurism, and to the securing of pressure on the vessel above and below the seat of operation. Five drops of an aqueous solution at 30° density (Beaumé) = 1·261 sp. gr., or 10 drops at 20° (1·160), was the calculation for each cubic centimetre (15 gr.) of blood to be acted upon (Giraldés). Dieulafoy has calculated even less than this. If too strong a solution, as of 45° to 50° (Beaumé) = sp. gr. 1·449 to 1·526, be used, the vascular coats may become inflamed or gangrenous, and if compression be omitted, embolism certainly may occur; and it will be found that some fault in these respects would explain most of the serious and fatal results which excited the vehement opposition of Malgaigne and others to the new procedure.

I think that scarcely sufficient importance has been attached to some of the successful cases—notably to one of aneurismal tumour of the orbit—recorded by an American surgeon (Brainard, Lancet, ii., 1853). The ligature of one carotid had given only temporary relief, and the actual cautery still less, but a complete cure resulted from several injections of the lactate of iron (8 gr. to 1 dr.). Brainard considered this salt more suitable than the perchloride, as acting more slowly, and with less irritation or tendency to suppuration. Bribosia (Brussels), in a special treatise on the use of coagulant injections, considers them best adapted for such aneurisms as contain more liquid blood than fibrine, and are situat d on the smaller arteries (*e.g.*, those of the cranium), and not too near the trunk. It must be acknowledged, however, that the general opinion of modern surgeons is adverse to the use of the perchloride as a coagulant in aneurism: Mr.

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Hart points out that compression of the affected vessel above and below the sac is a *sine quâ non*, and when this can be obtained usually safer methods of treatment may be employed (Holmes' System, vol. iii., 2nd Ed., 1870). Marsacci, in a recent work, came to the same conclusion; Gross and Erichsen also discourage it, though the latter speaks of curing with it a gluteal aneurism after some suppuration (Science and Art of Surgery).

Nævus—Erectile Tumour.—The application of ferric injections to these cases, though often successful, was soon found to require as much caution as in the more serious malady of aneurism. Thirty drops of the tincture injected into a nævus of the scalp caused erysipelas and sloughing before cure resulted (Med. Times, ii., 1853); in a few cases, situated about the face, immediate death resulted, this being sometimes clearly due to a clot formed in a large vein (Archives de Méd., Nov., 1868, Lancet, ii., 1867). In a few other cases cerebral embolism and softening or pyæmia followed (Lancet, i., 1874, Bull. de Thérap., 1873). On the other hand, Mr. Cooper Forster had good success after dividing the nævus-tissue subcutaneously and then injecting a "few drops" (Med. Times, 1853, p. 654). Mr. Morgan made an excellent cure of a large erectile tumour of scalp, using circular compression by plaster and pasteboard; and other good results might be adduced, and with very great care, might, I believe, be still obtained, but by common consent the operation has been discontinued on account of its danger (G. Buchanan, Lecture, Braithwaite, ii., 1875). A recent Paris thesis, however, re-directs attention to the subject, and presents it in a favourable light (Auguste Rigaud, Thèse, Paris, 1876).

Another and a safer method of using the perchloride in nævus is described by Leclerc, who applied it on pledgets of lint to the part, and obtained a cure at the expense of some erythema and suppuration. Guillot used it after first destroying the epidermis with caustic potash, and Guersant after vesication (Bull. de Thérap, t. lxvii.).

Varix.—Varices, without pain or ulceration, should seldom be interfered with by external treatment; but I have frequently known a very marked improvement in them while patients were under a regular course of 15 to 30 min. of the perchloride of iron, three times a day, for other affections. To judge by the

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recorded results of iron injections in varix, a large amount of success has been obtained with much less risk than in the last-named diseases; but yet the method is not generally approved by most modern authorities. Minor reports five good cases in which either the scrotum or the legs were affected, and three or four drops of a solution of persulphate (1 part in 4 of water) were sufficient for cure: the patient was in the upright position, and pressure was carefully applied above and below the seat of puncture (Ranking, ii., 1860). Sentoux, collecting 126 cases, found 100 cured, 19 relieved, 6 unaffected, and only 1 death. Denucé reports many successful cases (Moniteur des Sci. Méd., Nov. 15, 1862: Brit. and For. Rev., April, 1862): the perchloride was used with certain precautions. Desgranges thought the method, with ordinary care, to be free from danger—2 drops sufficed for the largest varicose lobule. He notes the improvement in varicose ulcers after the operation (Abstract, Brit. and For. Rev., ii., 1858). Morgan, of Dublin, succeeded in obliterating part of the saphena vein by injecting 5 drops of Monsel's solution in two places, carefully isolated: coagulum formed in fifteen minutes, and the case did well; in another, with irregular dilatation, and large varicose clusters about the knee, the same method of injection above and below was equally successful (Med. Press, July 14, 1869). Brainard's experiments on the formation of clot in veins under the use of sulphate were very satisfactory (loc. cit.); and Gross, speaking of nævus, and discouraging the use of perchloride, yet says that by "Monsel's solution any case of arterial or venous tumour, unless very bulky, may generally be promptly and effectually cured" (System of Surgery); this would seem sufficient to warrant a further trial.

Hæmorrhoids.—The perchloride is not only frequently of service as a styptic injection into the rectum to relieve bleeding from internal hæmorrhoids, but has been used sometimes by direct injection into the tumours, and has cured when other expedients have failed (Colles, Dub. Journ., June, 1874). Monsel's solution succeeded equally well in two cases of large external piles under Mr. Morgan (Med. Press, 1869). Hæmorrhoids occurring in anæmic or debilitated patients with copious bleeding, are in my experience often well treated by the internal administration of the perchloride.

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Relaxed and Discharging Surfaces—Relaxed Throat, etc.—The liquor ferri perchloridi, with a little glycerine added, is a good astringent locally and internally in catarrhal sore throat, and in relaxed conditions of fauces with mucous secretion: also in the œdematous, honey-combed condition which remains after follicular tonsillitis, or more serious throat inflammations.

Leucorrhœa.—In catarrhal and relaxed conditions of the vaginal mucous membrane, injections containing about 1 dr. of the tincture, or 10 gr. of sulphate of iron in each ½ pint of water, are often useful, but they have the drawback of staining linen. When the leucorrhœa is mainly dependent upon general debility, the internal administration of iron is often sufficient to relieve, without any injection; and in severe cases, occurring in anæmic and cachectic females with œdematous swelling (from excessive blood-losses), I have found the citrate of iron and quinine useful. Montgomery commonly recommended the pernitrate for leucorrhœa.

Gonorrhœa.—In the chronic stages of urethral inflammation, sulphate of iron forms a good injection. I recommend about 12 gr. with ½ oz. of laudanum, in 8 or 10 oz. of water—a little to be used three times a day; another form, recommended by Dr. Ringer, contains ½ dr. of the perchloride tincture, with 1 dr. of laudanum in ½ pint water. "It often speedily checks the discharge, and relieves pain on micturition." Barudel, writing from a large experience, would absolutely restrict the local use of perchloride to chronic cases, but he advocates it *internally* for all forms of urethritis, acute and chronic (Med.-Chir. Rev., i., 1859, p. 244). I would not myself recommend its use, even *internally*, in acute stages, but in the later ones of gonorrhœa, or gleet, full doses of 10 to 15 min. are of real advantage. Pereira recommended the remedy in combination with tincture of cantharides.

Phagedænic Ulceration.—The combined internal and external use of tinct. ferri perchloridi is advised by Ricord (Med. Times, i., 1859). Roget adduced instances of it curing chancre when applied early, and he maintained that the local use of an acid solution directly after exposure would prevent gonorrhœal, and even syphilitic contagion (Traité sur le

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Perchlorure de Fer, 1860, Paris). Rabuteau speaks favourably of the remedy—substituting only citric acid for the more irritant hydrochloric. He adopts the following formula—℞ Tinct. ferri perchloridi (30° Beaume, = 0·879 sp. gr.), 12 grammes; acidi citrici, 4 grammes; aquæ, 24 grammes: solve f. lotio.

Spermatorrhœa.—For seminal losses occurring in the young and the debilitated, tincture of iron is of great use; it should be given in full doses twice daily, and preferably not at night; plenty of outdoor exercise should be conjoined with its use.

Enuresis.—When this occurs in scrofulous children, or in those affected with worms, the perchloride or phosphate of iron gives ready help. One teaspoonful of Parrish's food, twice daily, in water is an excellent remedy for the nocturnal as well as the diurnal form when arising from irritability of the mucous membrane of the bladder. The alternation of iron with tincture of belladonna, or bromide of potash, acts still better if there be much spasm of the sphincter, and combination with ergot has also succeeded well (Guimaud, Bull. de Thérap., v. 63). Da Costa strongly recommends the bromide of iron in this malady.

Vesical Catarrh.—There can be no doubt that iron has a special determination to the mucous membrane of the urinary tract, and my own experience, as well as that of others, has proved its great value in catarrhal affections of the bladder. The carbonated iron waters of Schwalbach are especially recommended (Schmidt's Jahrb., 1877, Bd. clxxiv., p. 84), and are certainly less irritant than the acid preparations. In cases of catarrh and hæmorrhage, following the injudicious use of the catheter, weak injections of tinct. ferri, retained for about half a minute, check the hæmorrhage and cure the catarrhal condition (Med. Times, ii., 1870; *see* also Hæmaturia). Other instances of the value of iron in vesical catarrh are reported by Vigla (Med. Times, 1857–58).

Purulent Ophthalmia.—Bathing with ferric lotions and painting with the tinct. ferri have proved useful in chronic purulent conditions of the conjunctiva, and similar treatment has sometimes dispersed corneal opacities and healed scrofulous corneal ulceration (Gaz. des Hôp., Feb., 1862).

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Skin-Diseases.—In congestive and exudative forms of skin-disease much benefit may be obtained from the tincture of iron; thus, severe *pruritus* may be relieved by it (Lancet, ii., 1874, p. 715). In a case of chronic infiltrated *eczema*, when tarry preparations had failed, painting with the tincture, and afterwards with collodion, not only cured the intense itching, but also the malady itself, leaving only a dry and brown, but sound skin, and I have seen a case of pityriasis rubra in which the intensely red, dry, and scaly condition was more relieved by the application of this remedy combined with glycerine than by anything else. *Lichen agrius* is also relieved by it. Devergie drew attention to its value in chronic pustular disorders, such as *rupia*, *ecthyma*, and *impetigo* or pustular eczema (Med. Times, ii., 1860), in which it may be locally applied as well as taken internally. It is a good application for variolous pustules (Med. Times, ii., 1856, p. 498, Ranking, ii., 1866), and has favourably influenced the course of anthrax; a striking case is reported by Dauvergne (Bulletin, 1867).

Herpes.—Baudon found immediate good results from painting the vesicles of herpes with tinct. ferri perchlor. and glycerine; he recommended opening the larger vesicles for the application, but Gressy obtained equally good results without opening them, using a concentrated alcoholic solution, which gave rapid relief (Bulletin, t. lxiii). An ointment containing 6 to 10 gr. of sulphate of iron in the ounce is recommended by Palmer (Med. Times, ii., 1861, p. 24).

Ringworm.—The local use of iron in ringworm is an old practice, which has been recently revived (B. M. J., i., 1877). After cleansing the part, tincture of perchloride may be painted upon it three or four times, at a day or two's interval; a brown scale forms, which should be left undisturbed, glycerine will lessen the sense of dryness and constriction. I have found this treatment succeed in slight and recent cases; also in old ones, after more active remedies had been used, and it has the advantage of being not so unpleasant as some other applications.

Onychia—In-growing Nails.—Very successful results have been obtained by using the perchloride locally; for instance, a delicate girl who had suffered for several years and undergone

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removal of the nail and most ordinary modes of treatment without relief, was cured mainly by the use of an ointment made with perchloride, and a few applications of the solid compound: the latter gives pain and requires to be almost immediately washed away (Bulletin, 1853). The persulphate has been used in other cases (Med. Times, ii., 1868, p. 257).

Necrosis of Bone.—Injections of perchloride have a good effect in chronic sinuses; sometimes they act better when manganese is added (B. M. J., ii., 1871).

Ulcerations.—In chronic indolent ulceration the perchloride is a good stimulant; also the carbonate, finely powdered, has been applied in substance to old and excavated ulcers of the leg, and with good bandaging has succeeded well (Lancet, i., 1862). The salicylate of iron is said to make a useful lotion (Edin. Med. Journ., 1877).

Hospital Gangrene.—The perchloride and Monsel's solution have been largely used as local applications, especially in military practice. Salleron gives a very favourable report of these from experience in the Crimean hospitals and elsewhere (Buisson, Traité, etc., and Med.-Chir. Rev., ii., 1860). A "gangrenous throat" was also treated successfully with perchloride (Med.-Chir. Rev., i., 1861).

Polypus—Tumour.—The perchloride has been applied, it is said successfully, to the cure of polypus nasi by injections, and by continued contact (Boston Med. Surg. Journ., 1861). It has been injected also into the substance of tumours, and one case is on record when it was selected for injection into a laryngeal growth, but a drop of the fluid escaping, sudden death followed from laryngeal spasm (Union Méd., 1873).

Erysipelas.—Preparations of iron have been largely used, both externally and internally, in the treatment of this malady. A strong ointment or lotion of the sulphate (about 1 in 4) was recommended by Velpeau after many comparative trials with other remedies; it does not, however, always prevent the extension of the inflammation (Bulletin, 1855). Mr. Hulke recommends a lotion containing 10 gr. in the ounce (B. M. J., ii., 1871). The application of equal parts of liq. ferri and spiritus vini rect. would seem still more valuable (Oswald White, B. M. J., i., 1876); and Mr. Foster, of Leeds, obtained so

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much success by painting the ordinary tincture of perchloride over erysipelatous surfaces, that this plan became known as the "Leeds method;" it was applied also to inflamed lymphatics, breasts, etc., and seems to have been especially useful in erysipelas after vaccination (Lodge, Med. Times, i., 1875). Mr. Hamilton Bell was the first to publish cases of remarkable benefit from the *internal* administration of the same remedy, or rather of the old "tincture of muriate of iron;" he gave 20 to 30 drops every three hours, so that sometimes 2 oz. were taken in eight days (Edin. Month. Journ., 1852). In severe cases of "idiopathic" erysipelas, the spread of inflammation was arrested, the pulse lowered, and the fever relieved, and equally good results were reported by Balfour, Begbie, and other eminent men; and although Lehmann writes more recently in praise of the treatment (Lancet, i., 1880), we cannot concede to ferrum the "specific" virtue in erysipelas that has been claimed for it, nor is it the best remedy for every case. Todd curtly denied its efficacy (Med. Times, i., 1860); also H. Bennett and Estlander found it useless in traumatic cases (Med. Times, ii., 1871).

Dr. Marshall (Dover), after relating two acute cases well cured by 20-min. doses (and purging), states that he has found the remedy of *less* use in the traumatic form (B. M. J., i., 1872). The limited experience of Parkes need not weigh with us, because his cases received only 10-min. doses or less, and were therefore not tests of the method in question; but Aran, commenting on ten satisfactory cases recorded by Mathez (Thèse, Paris, 1857), points out that iron is not the best remedy for young, robust subjects with high fever.

It is fair to add that Mr. C. Bell still maintains its very great value in all forms of erysipelas, and attributes the failures of other practitioners to the use of too small doses, or of less excellent preparations; he states that under his own care patients have recovered so soon as the old "tincture of muriate" was substituted for the modern "perchloride." The former, made with sesquioxide and hydrochloric acid, contains more free chlorine and some protochloride of iron, but the present tincture of the B.P. is a more definite preparation; any difference in curative power can be ascertained only by clinical experience, and Mr. C. Bell's observations deserve

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attention (Edin. Med. Journ., Aug., 1876). Some observers have sought an indication for iron in the locality affected, finding it least useful for erysipelas of the head or trunk; but Pirrie has obtained the best results in such cases. I think that in choosing a remedy for erysipelas we should look rather to the general constitution of the patient, the nature of the tissues affected, and the character of the inflammation; thus, I find iron to be really the best remedy in anæmic, weak patients, or in lymphatic constitutions when there is rapid extension or flitting of the inflammation, when the affected surface is dark-red or bluish, when the pyrexia is slight, and when, owing to debility, the attack tends to linger.

In the erysipelas consequent on surgical operations it is also useful if the subject has been reduced by long-continued suppuration or other causes of exhaustion. I believe it has also some prophylactic power.

Diphtheria.—This malady is clearly allied to erysipelas, and has been successfully treated by the same preparations of iron, both locally and internally. Some of the earliest observers recommended the application of perchloride to the seat of exudation, on the ground of the effused membrane being parasitic (Jodin, Laycock), but fungus elements are not essential to diphtheria, and other physicians, regarding exudation as only one sign of constitutional infection, discouraged the use of such local means as might irritate: Trousseau, for instance, was disappointed in a strong tincture of perchloride used "as a caustic," and such application is not to be recommended; his remarks, however, do not apply to the use of a more dilute form, for blood-poisoning may occur from the affected surfaces, and I entirely agree with Dr. Heslop, Sir Wm. Jenner, Dr. Geo. Johnson, and others, that judicious local disinfection is very important and advantageous; various remedies may serve, but the gentle application of diluted ferric solutions has given very good results in competent hands. Dr. Nelson (New York), after ample experience of several methods of treatment, expresses the strongest conviction in favour of local applications of Monsel's solution (liq. ferri subsulphatis) diluted with glycerine and water; amongst forty cases thus treated he had only three deaths (New York Med. Journ., Jan., 1874). Dr. Billington, in an excellent practical

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essay, maintains that diphtheria is at first a local affection, and to be treated most successfully by early local disinfection; he has used lime-water, carbolic acid, etc., but gives a decided preference to the tinct. ferri perchlor., 2 parts, to 1 of glycerine; this he paints especially over the tough adherent membranes, and all adjacent parts. Three hundred cases treated upon this principle, show a large percentage of recoveries, and other physicians corroborate Dr. Billington's results (New York Med. Record, March 25, 1876).

Bertheau describes, in a recent thesis, a severe epidemic of "diphthérite" affecting 220 people (Indre), and in which the most useful of all the means employed was the local application of tinct. ferri perchlor. (30° Beaumé); when the membrane was unusually thick, this was painted on three or four times daily (Du Traitement de Diphthérite, etc., Paris, 1876). Dr. Fera applies the finely-powdered sulphate of iron freely to the affected part, and attributes to this the successful termination of eighty cases, whilst De Sabbata speaks in equally favourable terms of the use of an acid solution of the same salt (Lond. Med. Rev., Nov., 1876).

Referring now to my own experience, I find detailed notes of twenty-seven consecutive cases of diphtheria, in which the perchloride was used locally or internally; for the local application I employed an atomizer with equal parts of the solution and water, and continued its use for five to ten minutes every hour or two. In six cases no internal medication was ordered, but besides using the spray, the throat was swabbed out with solution of perchloride mixed with an equal part of glycerine, two or three times in twenty-four hours. The age in these six cases varied from five to nine years, and five of them recovered; but the attack lingered longer, and its course was more unsatisfactory, and convalescence more tedious than in other instances when internal treatment was conjoined: one child, aged four years, had nasal diphtheria, and sank on the third day. In another series of six cases, including children of from two to seven years, I gave minute doses of iodide of mercury ($\frac{1}{40}$ to $\frac{1}{30}$ gr.) and also liquor arsenicalis, and used freely a spray of perchloride of iron locally, and these six cases did well. The remaining fifteen, varying in age from two to ten years, were

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also treated by the spray, and in addition they received from 10 to 20 min. of the liquor ferri perchlor. every one or two hours, and of these cases twelve recovered. Nine of the total number had albumen in the urine on being first seen by me, and three hæmaturia; another had severe epistaxis, and all showed much exhaustion, with more or less dyspnœa and delirium. The iron given internally seemed to exert a sedative effect on the circulation, lowering the frequency of the pulse, and rendering it more full and forcible. I have never seen hæmorrhage, or albuminuria, or congestive symptoms of any kind which could fairly be traced to its action, and am indeed satisfied that its effect on the course of the disease is beneficial, though we cannot, any more than in erysipelas, consider it a "specific."

Admitting, however, that twenty-seven cases do not furnish sufficient basis for a positive conclusion, it will be desirable to review briefly the experience of previous observers. This we shall find to be strongly in favour of the iron treatment. Dr. Godfrey, of Enfield, reported three cases of "diphthérite" treated by the perchloride at the very commencement of the epidemic, and speaks of it as the best remedy (Lancet, ii., 1857). It was strongly recommended to the profession at about the same time by Aubrun, in France, and soon after by Dr. Heslop in this country (1858–59). The mortality before that date was most severe—thus, of twenty-six cases related by Aubrun, and treated without iron, twenty-two died. In the next series of cases, in which he used the remedy both internally and locally, out of twenty-seven three only died, and in another series of twelve cases there were no deaths at all (Gaz. des Hôp., 1859); nor does it seem that any natural lessening of virulence in the epidemic accounted for this striking and suggestive difference.

Aubrun was most particular in his method of administration, ordering one or two teaspoonfuls of a solution every five to fifteen minutes through the day and night, for the first three days of the attack, "because usually membranes would be detached, or would cease to form after that time"—then the medicine could be taken less frequently (Comptes Rendues, 1860, t. li.). Da Silva, commencing with only the local application of

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perchloride, soon found improved results from using it internally, and recorded many successful cases (Gaz. des Hôp., Fev., 1859). Isnard was a still more earnest advocate for this treatment. Following Aubrun in the principle that "iron strengthened the vital power" he reasoned also that it might prevent exudation just as it might hæmorrhage, rendering the blood more plastic and also less liable to contamination (blood-poisoning): and acting as an alterative on the mucous membrane of the respiratory tract it was better than alkalies, for they were too slow in action and too lowering; it should be given early and repeatedly so as to influence the blood-condition as soon as possible; in support of his reasoning he adduced thirty-nine cases, of which thirty-five got well in a natural manner, and two after tracheotomy. Dr. Heslop, after referring to the then excessive mortality of diphtheria, and the failure of all accepted modes of treatment, records several striking cases of recovery from almost hopeless conditions under the internal use of tinct. ferri perchlor: he conjoined with it local applications of dilute hydrochloric acid: at the same time that he praises the remedy, he cautions against regarding it as "a specific" (Med. Times, i., 1858). Mr. Pound relates equally favourable results (B. M. J., i., 1858), and Mr. Houghton (Dudley) contributes four striking cases of recovery under very unfavourable conditions (Dub. Journ., Feb., 1859). A very severe epidemic in the fen country was controlled, according to Mr. Stiles, by the same treatment (B. M. J., ii., 1858), and of fifty-six cases reported by Mr. Prangley, two only died after commencing the remedies: he used iodine locally and perchloride with potash chlorate internally. Mr. Salter contributed additional testimony to the same effect, and altogether the change of tone, and of the amount of mortality recorded in writings of this period, abundantly testify to the benefit derived from iron tincture, allowing even for accidental circumstances. Mr. Fisher attaches much importance to the use of a preliminary emetic or purge (Lancet, ii., 1862), and Dr. George Johnson, agreeing that treatment with perchloride internally is the most successful of all, conjoins with it local chlorine applications (Lancet, i., 1875). Sir W. Jenner, careful to place mere medical treatment in a subordinate position, states that in his experience benefit has accrued from

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the perchloride, as from other medicines, only in certain cases suited for it (Clinical Lectures), whilst Dr. Wade expresses some distrust of the remedy, fearing it may increase the renal congestion, for he has found, in fatal cases, more pronounced alteration in the kidneys of patients treated by iron than in others (Lancet, ii., 1862): he would prefer iodide and chlorate of potash. Certainly there are arguments in favour of Dr. Wade's view, but it is not supported by my own experience, and I think it will be conceded, that the illustrations and authorities already given, furnish ample evidence of the value of perchloride of iron in diphtheria. The appearance of albumen, blood, or tube-casts in the urine does not contra-indicate the use of iron in this disease, but on the contrary calls for its administration; and when blood or tube-casts are present the iron should be given in conjunction with nitric or hydrochloric acid: under the same conditions stimulants should be judiciously regulated, but seldom withdrawn. Ordinary diuretics are injurious, but as a rule demulcents should be freely taken. Patients should be well nourished with beef-tea, soups, eggs, milk in any form, chicken panada, etc., and ice sucked or swallowed is very agreeable and relieves the painful condition of the fauces: the skin should be kept clean and warm, and the house and room well ventilated; aperients, as a rule, weaken the patient and cause an extension of the exudation in the throat; all these and other matters as they arise should be carefully attended to during the administration of any iron preparation in diphtheria.

Scarlatina — Scarlatinal Angina — Variola.—In many of these cases I have used the perchloride internally, and applied it to the throat mixed with equal parts of glycerine and water, or through an atomizer, with satisfactory results, but I recommend it most in cases which assume a malignant or putrid form; benefit is often obtained by painting the swollen cervical glands with the liquor ferri.

I have treated many cases of articular inflammation occurring during scarlatina, and closely resembling articular rheumatism, showing high temperature and great prostration,—with 5 to 10-min. doses of tincture of perchloride three or four times daily, with excellent results, the joints being also painted with the liq.

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ferri perchlor. Meade writes to recommend the same medicine in frequent doses of 10 to 15 min. (Med. Times, i., 1858); and Arlidge believes it to be not only valuable as a remedy during the attack, but as a preventive of dropsy (B. M. J., ii., 1871). Fears have been expressed—as in the case of diphtheria—of its increasing renal congestion, but I have never seen injurious effects which could reasonably be traced to it, and Dr. Crighton makes the same observation (B. M. J., i., 1869). He considers that any risk of this kind may be obviated or lessened by combining liquor ammoniæ acetatis with the iron compound, thus assisting the action of the skin, and I believe the combination to be very serviceable in febrile and inflammatory cases.

The perchloride has sometimes been used with very good effect to relieve the throat-condition in variola (Med. Record, Jan., 1873), and the course of the malady itself seems to have been favourably modified; half-drachm doses of the tincture were given every four hours in a severe case occurring in the seventh month of pregnancy, and the patient did well (Ranking, ii., 1866).

Rheumatism, Acute and Sub-acute.—To ascertain the value (or the reverse) of iron in acute rheumatism, I must refer rather to the experience of others than to my own. Pétrequin seems to have been the first to use it, and he reported marked advantage from doses of 40 to 80 min. given in the course of twenty-four hours; he prescribed it with lemonade, and he made trial also of the sulphate and the citrates (Traité Pratique des Eaux Minérales, Thèse, Paris, 1855, p. 533). Dr. Russell Reynolds—led to use the remedy by consideration of its value in erysipelas—brought before the profession a series of eight cases in which the average duration of high temperature was shortened (to five and a half days as against fifteen), and in several of which pain was quickly relieved and no discomfort produced; but, on the other hand, one patient died comatose, after delirium, and another of pneumonia and pericarditis, whilst a feeble or intermittent pulse of 56 to 60 caused anxiety in two of the others; it is to be noted that most of these patients had some cardiac inflammation before coming under treatment, yet the results can scarcely be considered favourable (B. M. J., ii., 1869). In another series of cases, however, Dr.

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Reynolds was able to record greater success; thus, out of a total of sixty-five, 44 per cent. of first attacks were convalescent in the course of a week, and most of those suffering from second, third, or fourth attacks in the second week; one-half of the whole number were severe cases, yet the temperature became normal within fifteen days: hyper-pyrexia occurred in three, and proved fatal in two instances (B. M. J., ii., 1872).

If we examine other observations that have been published on this subject, we find satisfactory results obtained by Mr. Bott (B. M. J., i, 1870), and the record of six cases successfully treated with perchloride by Dr. Dyce (B. M. J., i., 1876); and Dr. Rose finds the remedy "prophylactic of rheumatism" (Lancet, ii., 1871), but on the other hand, of three cases treated by Dr. Buck, one had urgent dyspnœa, and one unusual cardiac pain (B. M. J., i., 1870), and of three cases recorded by Mr. Greene, one died with cardiac lesions, and one had tetanic spasms, so that it seems desirable to ask (with Dr. Trestrail) whether the perchloride given in acute rheumatism may not increase the disordered blood-condition, and the tendency to embolism, and to embarrassed pulmonary circulation: at least, we must say that there is at present much more doubt as to the suitability of this remedy in acute rheumatism than in erysipelas or diphtheria, and it has not commanded the same amount of professional confidence; and yet when the urine is alkaline (as in several of Dr. Reynolds' cases), and the patient is very anæmic and feeble, tincture of steel seems quite appropriate; also rheumatic pain is often relieved by it, and it has decided value in the anæmic condition following acute attacks, and in subacute and chronic varieties of rheumatism. The late esteemed Dr. Anstie drew attention to its power of cutting short subacute cases as observed amongst the out-patients at the Westminster Hospital; in such as were really rheumatic (and not gouty) in character, with sallow patchy face, deep furring of tongue, oily moisture of skin, obscure aching of limbs, slight rise of temperature, and trouble of respiration, he found that 30 to 40-min. doses, given three to six times in the twenty-four hours, often arrested the progress and relieved the symptoms in a few days; this occurred in seventeen cases out of twenty-nine (Practitioner, Sept., 1871).

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Chronic Rheumatism.—Ferrum is useful in primary chronic rheumatism, also in cases when the patient is much reduced in strength and flesh after an acute attack; it should be continued for some time, for its favourable effects are but slowly produced.

Rheumatoid Arthritis.—Dr. Garrod recommends iodide of iron "in some cases of rheumatoid arthritis, especially when the joint-pains are increased by the heat of the bed." I have tried it, but have not myself seen good results from it.

Anæmia.—The various preparations of iron form our most dependable remedies in ordinary and simple cases of anæmia and chlorosis, and indeed their good effects are usually so evident that iron was, at one time, considered a panacea for all forms of these affections, but in reality, if prescribed injudiciously, it may not only fail to cure, but may produce ill-results, and observation of such instances has led some observers to depreciate a remedy which had been considered so universally curative. Thus, Trasbot has recently denied to it any reconstituent or hæmatinic power, whilst Dujardin Beaumetz holds the employment of iron in anæmia "une grande illusion thérapeutique" (Journal de Thérapeutique, 1876). The former observer states that in experiments on dogs he obtained better hæmatinic results from lime phosphate, coffee, and wine, than he did from iron, which proved simply exciting; and Dujardin Beaumetz relies upon an argument of C. Bernard's, that even if the normal amount of iron in the blood of chlorotics be diminished, it is only by a very small amount (10 or 20 centigrammes) more than which is introduced daily in the food: but the true answer to such observations is, that all theory, and even all physiological experiment, must stand or fall by the clinical results obtained on man (Mialhe and others in Gaz. Hebdom., Mars, 1876), and in the majority of cases these are satisfactory. The objections of Trousseau were limited to the use of iron in "false chlorosis"—that is to say, in cases when the suppression of the menses, pallor, etc., were really connected with incipient phthisis, which malady he found to be accelerated by ferruginous medicines (Traité, vol. i.) His observations have been corroborated by Millet (Bulletin, 1862), but the cases quoted by the latter author illustrate mainly the injudicious domestic use of certain preparations without due examination of the patient, and his

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remarks apply only to the abuse, not to the medical and proper prescription of the remedy.

By the terms "anæmia" or "aglobulia," we understand a condition in which the red blood-corpuscles are fewer than in normal health; instead of being in the proportion of 130 parts per 1,000 of the blood, they may be at 80 or 60, or even less, and this may arise from direct loss of corpuscles (hæmorrhage), or from insufficient formation of new ones on account of disease, or bad air, or unsuitable food, and under such conditions the corpuscles that are formed are small and misshapen. The most marked symptom of anæmia is pallor, which affects the mucous membranes as well as the skin, and may be noted in the conjunctivæ, the gums, and the lips; other symptoms are difficulty of breathing, especially on exertion, lassitude, mental and bodily, malaise, restlessness, dyspepsia, constipation, headache, neuralgia, and palpitation: the pupils are commonly dilated. Some varieties of anæmia benefit by iron more than others, and it is not easy to lay down definite rules concerning them. If there be much dyspepsia this should first be treated by other appropriate means; but on the other hand, the simple atonic dyspepsia of anæmic persons is very amenable to iron. Congestive headache is a contra-indication, but the pulsating acute headache which follows profuse hæmorrhage really requires iron medication; important points for securing its good effects are, to obviate constipation by aperients if necessary, and to secure sufficient oxygen for the proper assimilation of the remedy, and I think that many failures in the treatment of anæmia are traceable to want of management on these points.

Direct anæmia dependent upon excessive hæmorrhage; or the indirect anæmia which follows loss of animal fluids generally (such as in obstinate leucorrhœa, empyema, and purulent formations, seminal losses, profuse perspiration, diarrhœa, prolonged lactation, or too frequent pregnancies); also the anæmia produced by acute disease, such as rheumatism, and that connected with inanition when the albuminous constituents of blood are really most deficient; all these forms, though complicated with extreme debility and general hydræmia, may gradually improve with good food, rest, and pure air (especially if the cause be removed), but iron, given in suitable

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doses and not so as to disorder the stomach, will greatly assist and hasten recovery.

In other cases, the best dietetic measures alone are insufficient, and iron is indispensable for cure; in the congenital anæmia of children born after profuse uterine hæmorrhage, or whose parents were affected with anæmia, tuberculosis, constitutional syphilis, or other exhausting diseases, iron is of special value; also in strumous and rachitic cases (when the iodide or the phosphate is the most suitable form), but it requires to be continued for a long time. I have always found, in the treatment of simple anæmia, that when, under the judicious use of iron, etc., the blood assumes a healthy aspect, and the formidable symptoms disappear, if the iron medication is not persevered with for a considerable time longer, the malady returns in an aggravated degree. Anæmia arising from severe and continuous mental strain is best treated by the phosphate conjoined with cod-liver oil—many cases have come under my observation when this treatment proved highly beneficial. In the anæmia due to mal-hygiene, to sedentary pursuits, prolonged residence in a town atmosphere, or continued exposure to carbonic acid, iron compounds are also markedly useful. In all these forms their advantage has been often verified by the enumeration of the blood-corpuscles, and estimation of the amount of colouring matter.

Idiopathic or "Pernicious" Anæmia is an extremely interesting but obscure form of disease, connected mainly with the glandular system; it is insidious and fatal, and iron, at least in the forms usually employed, has seemed to possess little or no remedial power against it: arsenic, and perhaps phosphorus, have succeeded better (*v.* p. 448). Quite recently, however, benefit has been reported even in this malady from the hypodermic use of iron, and Da Costa has further exemplified the value of this resource by the cure of an obstinate case of chlorosis with hypodermic injections of "dialysed iron" in 15-min. doses (B. M. J., i., 1878). I should consider this an additional proof that in many cases where iron is said to have failed, it is because of its not being given in a form that can be assimilated.

In ordinary goître, iron alone is inefficient, and in *exophthalmic goître*, although anæmia is commonly a marked symptom, I

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have not seen much advantage from it. In the anæmia of incipient phthisis it must be given with caution (*v.* p. 608); and in that connected with diabetes and malignant or malarious disease, its effects, though often good, are rather uncertain.

The success of iron in anæmia will clearly vary with the different causes, forms, and degrees of the malady, and an accurate knowledge of them is a great help towards cure of the disease, and confidence in the power of the drug. Cases coming under treatment at an early stage usually admit of a favourable prognosis, but when the anæmia is congenital, or occurs at the climacteric period, recovery is more uncertain, and the anæmia of old people (unless when directly consequent on an acute illness) is the least tractable of all; intercurrent disease, especially if of febrile or inflammatory character, renders the prognosis as to the anæmic condition, very doubtful.

It is worth while, even at the present time, to refer briefly to two of the earliest facts which fixed the value of iron in suitable cases of anæmia. An endemic malady, apparently unknown at the time (1804), attacked the workers in the mines of Anzim (coal); it was probably anæmia from carbonic acid poisoning, for they became pale, feeble, short of breath, and died of asthenia, or chest-disease. Treatment by quinine, opium, good food, etc., failed to relieve, and four cases were sent to a hospital in Paris for the opinion of the physicians: of the four men, one died shortly, and at the section, Hallé, noticing the exsanguine appearance of the body, thought of iron, and prescribed it for the others, who got well, and returning home cured their companions with the same remedy (Quevenne, Mémoire, etc.). Something similar occurred at the mines of Schemnitz (metal mines), where the workers at one time died rapidly with "anæmia, asthma, phthisis, and dropsy," when the epidemic was stayed with iron medicines by Hoffinger (Ozanam, Histoire des Epidemies).

Chlorosis.—The relationship of chlorosis to anæmia is not exactly clear, but it has this in common with it—that the number of red corpuscles is diminished, and that those which are visible are mostly small, some are shrivelled and irregular, and all are pale-coloured; the serum is in excess: in causation, also, it is allied, as it occurs often in young girls obliged to live in close, ill-ventilated rooms or workshops, and it has also, some-

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times, seemed directly due to the hæmorrhage of the first menstruation (Wade).

As an entirely primary disease it seldom occurs in any but unmarried women, and chiefly from thirteen to twenty-four years of age; if it occur later in life, it is usually traced to frequent confinements coming rapidly one after another, and especially if the women nurse their children. It is connected with deranged menstruation and certain sexual causes which we are at present unable to distinguish accurately: it occurs either before the menses have appeared, or after symptoms of disordered menstruation have continued for some months; dysmenorrhœa and leucorrhœa are frequent precursors of it. It is often hereditary; the children of tuberculous parents and delicate women with irritable nervous systems are the most susceptible to it: sometimes, in exceptional cases, menstruation is too frequent and profuse. The patient is subject to most of the symptoms already described under anæmia, especially dyspnœa, palpitation, headache, giddiness, and dyspepsia: the face is œdematous and pallid, with a greenish hue; the condition lasts longer than ordinary anæmia, and relapses are still more liable to occur.

The cure of this affection is often readily accomplished with suitable diet, pure air, exercise, healthy mental occupation, and a steady course of iron, which latter is almost a specific in all simple cases. It was formerly thought that the metal acted by supplying some deficiency in the blood, or at least by directly increasing the number of corpuscles. Béhier considered that it was always indicated when he found, on microscopical examination, that the red globules were reduced to a proportion of 80 per 1,000, and to some extent this is a guide. General improvement will usually occur *pari passu* with an increase in their number towards the normal amount, but it must be understood that the action of iron is not simply a mechanical or chemical one. Claude Bernard has shown by analysis that the metal, as such, is not always deficient in amount in chlorotic blood, and Hayem has shown that the number of corpuscles is not always diminished before, nor increased after the use of iron; on the other hand, the latter observer has clearly shown that the size, and colour, and "vital character" of the corpuscles are

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remarkably improved by it. It acts, therefore, as a stimulus in some manner peculiar to itself, or, as others have expressed it, it has a "dynamic or vital influence" which chemistry alone will not explain (Trousseau, etc.; *see* also Physiological Action).

With regard to the preparation that is most suitable, we may refer to the observations of M. Coste. He made trial of different forms in 118 cases, fifty-five being of chlorosis, and he concluded that the choice of any particular one was not in itself important, if irritation of the stomach did not result—every preparation that did not irritate produced the good effects of iron; the reduced metal, taken at meal times in small quantities, proved on the whole the most satisfactory form, and the experiments of Quevenne, and the observations of Chomel, Trousseau, and others, are to the same effect. Sydenham obtained remarkable success with iron filings and iron wine, and, as a rule, we may say that the simpler the form used the better, and chemical theories as to solubility, etc., do not guide as to the therapeutical result. The ferrum redactum, the oxides and proto-salts, especially the carbonate, are certainly to be preferred in the earlier stages of chlorosis, unless the occurrence of mucous or other discharges indicate a necessity for astringents: sometimes the metal itself causes unpleasant eructation, and the oxides are liable to adulteration, and hence the recently precipitated carbonate, which is not astringent or irritant, is preferred by many, and in the form of mist. ferri comp., or Griffiths' mixture, has had great repute in the treatment of anæmic amenorrhœa. The "Pilules de Blaud" contain carbonate of potash and sulphate of iron, and have for many years retained a high reputation in the treatment of chlorosis, especially on the Continent (Niemeyer): his original memoir, recording thirty successful cases, is republished by Bayle, and will repay perusal (Biblio. de Thérap. Journ., iv., 1837). I have but little personal experience of the value of the hydrated oxide, or "dialysed iron," which seems pure and non-irritant; the doubts expressed about it seem to be mainly theoretical (Bouchardat, Bulletin, Jan., 1878, Med. Times, i., 1878, B. M. J., ii., 1878). I have had excellent results from a protochloride, and sometimes the citrate with ammonia will be borne better than any other. Dometz specially recommends an albuminate (*see* Prepa-

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rations), and in the anæmia so common in Japan, and traceable to intestinal catarrh, found it better borne than any other form. I have seldom seen the astringent forms, when given in a right dose, and at a proper time, produce any injurious effect on a weak or irritable stomach; indeed, in many such cases I have found them particularly suitable, and we need not be deterred from their use by fear of irritating effects: astringent preparations, such as the perchloride and sulphate, should be used in cases of "menorrhagic chlorosis," for it is found practically better to treat the anæmia in such cases than to omit iron for fear of increasing hæmorrhage (Trousseau). This applies especially to cases where the discharge is profuse and frequent, but pale and imperfectly coagulating; but even when it is florid in character, iron may be ordered with advantage, if due attention be first given to such symptoms as hepatic congestion and constipation. Astringent preparations are also useful if there be a tendency to palpitation, general relaxation, or undue discharges of any kind, and also when impairment of nerve-power is a marked symptom. Aloes is often added to reduced iron or iron carbonate, in phlegmatic subjects, and sulphate of magnesia to medicines containing iron sulphate, especially if the patient be *plethoric;* sometimes small doses of belladonna will regulate the bowels, preventing constipation better than either of these aperients. In all cases, success will depend not upon giving a large quantity of the medicine, but upon *securing its due assimilation;* for this purpose, air and exercise are important, and fatty food certainly aids the digestion of iron (Nasse, B. M. J., ii., 1877). Jeannel found that an oleo-stearate of iron, prepared with the sulphate and white soap, was very well borne: nitro-hydrochloric acid baths also favour the absorption of iron (Chambers, Med. Times, i., 1862).

It is important in all cases to continue the remedy sufficiently long, and not to omit it on the first symptoms of improvement; permanent benefit can seldom be expected under five or six months.

In cases where iron had not been given properly, and when it afterwards failed to produce due effect, I have found great advantage from *arsenic* alone, or in conjunction with iron. Manganese has also been recommended (Pétrequin).

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Anæmia of Pregnancy.—We consider iron not a direct, but an indirect emmenogogue, by virtue of its improving the blood-condition; but since the continued use of the mineral can cause congestion of the pelvic, as well as of other organs, it becomes an important question as to whether its use is admissible or is dangerous during pregnancy. Certainly the perchloride has been in frequent popular use as an abortifacient, but the evidence of its power for this purpose is not cogent (*v.* p. 575). Its use has often furnished occasion for prosecutions, but few cases of its really causing abortion are recognized, and in many of these, as well as when the sulphate has been used, the effect seems to have followed from violent irritation of the intestinal canal. It is true that cases in which abortion is deliberately produced would not, as a rule, find their way into the public press; but allowing for this, I find a general impression gaining ground that iron may be taken during pregnancy without injurious effects. Ramsbotham and Barnes recommend it, the latter stating that he has never seen harm from it (Lancet, i., 1874, p. 768). It was stated during a recent trial that 10-gr. doses of ammonio-citrate of iron were dangerous to a pregnant woman, but Dr. Woodman contradicted this from his own experience, and Dr. Graily Hewitt said that he and others constantly prescribed it during pregnancy (B. M. J., i., 1870). Dr. Bassett brought before the Obstetrical Society many cases illustrating the value of the citrate and tartrate of iron in averting miscarriage and serious hæmorrhage in delicate women, and there seems to have been no difference of opinion upon the subject (Lancet, i., 1874, p. 768): he considers that the addition of an alkali to the iron medicine renders it better borne, and points out that aperients should be given occasionally during the course. I can corroborate the experience of Dr. Bassett, and I think that the neutral preparations of iron are the most suitable during pregnancy, though some observers speak well even of the perchloride (Day, B. M. J., i., 1870). Trousseau remarks that iron has no direct emmenogogue power, and Hirtz has never seen any objection to using iron in the anæmia of pregnancy, though he has not found it very useful (Dict. de Méd.); altogether we must conclude that the older fears of injury from its moderate medicinal use were unfounded.

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Phthisis.—A great deal of fear has been expressed about the use of iron in this malady, and it has been said by eminent observers to hasten and aggravate its course, especially when given in full doses and in the early stages (Trousseau, Millet, Bull. de Thérap., 1862, etc.). If there be acute pyrexia and evidence of pulmonary congestion, leading to florid hæmoptysis, then I think that iron is better avoided, because it can increase blood-pressure and congestion, and stimulates blood-formation, and in any case it should be given with much caution during the early stages of the malady, and special attention should be directed to supplying at the same time any deficiency of fatty food, and to securing a due supply of oxygen (Dobell, B. M. J., i., 1867). Iodide of iron is one of the best preparations to use, especially in "scrofulous phthisis," and it should be combined, if possible, with cod-liver or other oils. In *later* stages of phthisis, all are agreed as to the value of iron in relieving many of the most distressing symptoms and much assisting any measure of recovery that can be obtained: the astringent preparations control purulent formations and discharges of various kinds, such as expectoration and passive hæmoptysis, diarrhœa, and profuse perspiration, and they often improve the strength and the appetite. Bonorden used the sulphate in a number of cases, giving from 2 to 4 gr. every two hours for several days at a time: the dose seems large, but he obtained very good results (Schmidt's Jahrb., May, 1852). Dr. Thompson employed chiefly the perchloride at the Brompton Consumption Hospital, and calculated the effects of iron medication in more than 1,500 cases,—54·6 per cent. were found "improved," 23 per cent. much improved, and only 21 per cent. not improved. He does not give the details of any cases, nor does he mention the stages of the disease when iron was used, but states generally that the patients grew stronger, and were able to eat better, and suffered less from flatulence, diarrhœa, night-sweats, and hæmoptysis: he considers that iron is clearly required in the treatment of phthisis, because "it improves the condition of the blood," and he advocates its continued but moderate use "as a food" (Practitioner, vol. i.). Others have written special treatises in favour of this medication. Dr. Cotton obtained favourable results from the iodide and ammonio-citrate (Med.

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Times, i., 1860), and Sir Thomas Watson recommends iron in non-inflammatory forms of phthisis, "and finds the mist. ferri comp. very useful when it is well borne:" if sweating be profuse, he uses the perchloride. Dr. Cameron recommends the basic iodate of iron as better than the iodide: it contains 51 per cent. iodine and 11 per cent. iron (Dub. Quart., May, 1869).

Chronic Bronchitis—Emphysema.—In chronic bronchitis, with profuse expectoration, I have found iron compounds, especially the perchloride and the phosphate, often useful; besides improving the general health, they lessen the amount of secretion and modify its character. In emphysema the perchloride is often valuable for its tonic power and its action on the capillaries, as well as for improving the impaired blood-condition.

Cardiac Disease.—Cardiac pain and dyspnœa may often be relieved by iron preparations, which act probably in an indirect manner—*i.e.*, by improving the blood in the first instance, hence their advantage is seen most in cases of anæmia: in such conditions, occurring after acute rheumatism, even the physical signs—murmurs, etc.—may improve under a course of iron (Jones, Med. Times, 1861). Increased frequency of pulse is not, in itself, a contra-indication, but only when increase of tension is also detected. In mitral disease with dropsy, the acetate or perchloride is especially useful if combined with diuretics: in fatty degeneration of the heart, in any form of chronic valvular disease, and in dilatation, iron is often serviceable, especially when combined with digitalis.

Serous Effusions—Dropsy.—Iron acts powerfully in dropsy resulting from a state of anæmia or hydræmia of the system, and good effects may be obtained from 3 to 5 gr. of ferrum redactum taken at meal times, or 15 to 30 min. of tincture of perchloride about half an hour after meals. Dropsy dependent upon mitral disease is best treated by iron and digitalis (in addition to purgatives), and dropsy connected with albuminuria is very amenable to the same combination: it should not be used during acute renal congestion (cf. Rotta, "Fer en Hydropisie," Annuaire de Thérap., 1857). Husemann praises it in "cachectic dropsy," and in that form which is connected with chronic nephritis and amyloid degeneration of the kidney. Dr. Anstie has written strongly in favour of the

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tincture of iron in chronic pleuritic effusion, and my own experience quite corroborates his observations.

Albuminuria.—The astringent preparations of iron are often exceedingly useful in controlling the loss of albumen by the urine: we must remember, however, that it is also possible to do harm by these remedies in renal diseases, and I have seen congestion increased by recourse to them during the acute stage. The best effect is certainly obtained at the decline of this stage, when the urine is free from blood or inflammatory casts, when pain in the back, and in the head, and the general febrile conditions are relieved, but the patient is pallid, weak, and suffering from more or less anæmia and dropsy; then the value of such preparations as the perchloride or acetate is often very marked, both as regards the general health and the discharge of albumen. Dr. Hassall, indeed, attributes these good effects more to a reconstituent action on the blood, "than to any direct astringent power, because he could not detect either the metal, or the acid combined with it (hydrochloric), in his analysis of the urine" (Lancet, ii., 1864). Dr. Parkes was one of the first to show, by quantitative analysis, the gradual lessening and final cure of the discharge of albumen under the influence of perchloride: this was in a subacute case, when the early inflammation had subsided, and hospital nursing and the use of gallic acid had quite failed to relieve (Med. Times, ii., 1854). In all cases of this kind it is desirable to feel one's way with iron preparations, to begin at first with a small dose; and the recommendation of my late friend Dr. Basham, to combine with it the acetate of ammonia, is a very good one. The addition of ergot will increase the astringent effect (*v.* Gaz. Méd. de Lyon, Oct., 1862), and in albuminuria following scarlatina, especially when dropsy is present, tincture or infusion of digitalis, alternately with tincture of perchloride of iron, is a very valuable prescription: it increases the flow of urine, at the same time that by its action on the blood and the capillaries it restrains the transudation of albumen: Dr. Goodfellow and Dr. Cheadle have reported favourable results with it (Med. Times, 1871, Ranking, i., 1873).

In chronic forms of albuminuria iron will require consideration: it is often extremely useful, improving the blood-condition

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more than any other remedy, and Dr. Lionel Beale testifies to its good effects even in chronic structural change and fatty degeneration (Med. Times, i., 1865, p. 29), but the cases in which it does harm are those with granular kidney, when the heart is large, the pulse hard and of high tension, and when there is much tendency to headache (Dickinson, Lancet, i., 1876). Hirtz says that he has seen it hasten a fatal termination by uræmia, lessening the amount of urine, and increasing that of urea (Nouv. Dict., Art. Fer), so that its effects should always be carefully watched: a very important point when ordering iron in any case of albuminuria is to obviate constipation.

Chyluria.—The perchloride of iron has sometimes proved very useful in cases of this kind, even when they have lasted for several years (Lancet, ii., 1862).

Diabetes.—Carbonated iron waters are much esteemed as adjuvants in the management of diabetes; and Dr. Mackey informs me that the bromide of iron, or rather a combination of bromide of potassium and citrate of iron, has given better results than any other medicine in his experience. Of course, the diet and hygiene must be regulated, and when we can more accurately distinguish the varieties of the malady we may find that certain medicines are more appropriate to some forms than to others, but meanwhile I believe the bromide of iron is available in any ordinary chronic case: I have frequently seen the general health improve, and the amount of sugar grow less under its use.

Dyspepsia.—Although iron is contra-indicated in cases of acute and irritative dyspepsia and mal-assimilation, yet certain forms of "atonic dyspepsia" which are connected with debility and impaired blood-condition are well treated by it. There are the general symptoms of anæmia, and also a sense of weight and heaviness after food, and impaired appetite, rather than of acute pain, and the preparations usually most suitable are such as the citrate or ammonio-citrate combined with soda and calumba, or reduced iron with nux-vomica: the headache which often accompanies this condition is also relieved by these medicines: when there is much general relaxation, or gastric catarrh of chronic character, the perchloride, preferably with quassia, is valuable. In the dyspepsia of chlorosis, iron will

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often not agree if the tongue be furred, or the urine loaded: but if these conditions are present only in a minor degree, then the citrate may be used in effervescence with soda (Budd, On Dyspepsia). Dr. Milner Fothergill, in an article "When not to give Iron," insists on the importance of clean tongue and freedom from "biliousness;" and he quotes Sir J. Fayrer to the same effect (Practitioner, 1877): he remarks also that toleration of it diminishes with age.

Diarrhœa.—In simple cases, occurring in weakly children, and continuing after preventable causes have been removed, the vinum ferri is a mild but very useful astringent tonic, which is often sufficient both to stay the discharge, and to prevent its recurrence. In more serious cases of chronic mucous diarrhœa with slimy, bloody, offensive stools, and tenesmus, whether met with in adults or in children, the best preparation is the liquor ferri pernitratis, in doses of from 1 to 5 drops, as originally recommended by Neligan, and I have seen also much benefit from its use in the colliquative diarrhœa of phthisis. Dr. Graves specially advised it in the "nervous diarrhœa" which is liable to occur from emotional causes, and is more frequent in women: in cases with nausea and impaired appetite, calumba may be well added to the iron (B. M. J., ii., 1870, Dr. Cooke).

Dysentery.—I cannot recommend iron preparations during the acute stage of dysentery, for I believe there are much better remedies, but some practitioners have found iron valuable. Bandon reports twelve cases suffering with tormina and very frequent sanguineous stools, which were treated by 12 to 30 min. doses of steel tincture internally, at the same time that about 12 min. with water (and sometimes laudanum) were injected; these cases were much relieved or cured within a week. (Bull. de Thérap, fo. 71). Blanvillon corroborated these results (Gaz. des Hôp., No. 130), and the same medication was largely used during the last German war (Lancet, ii., 1870): as a general rule, it is better restricted to chronic stages of dysentery, and for the anæmia and debility attendant upon this condition it is of great value.

Cholera.—Iron is one of the numberless remedies recommended for cholera, but I have very little personal experience of its use: it would, of course, not be depended upon alone, and

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Robiquet has reported a number of successful cases treated by the citrate and by reduced iron with quinine, frictions, and warmth, and nutriment being also conjoined (Journ. de Méd., Oct., 1873, Practitioner, vol. xi., p. 452).

Nervous Disorders—Hypochondriasis, etc.—The nervous system naturally suffers when it does not receive a due supply of healthy blood: depression and a sense of oppression will be felt, and hysterical or hypochondriacal symptoms will be more or less pronounced: in such cases, iron is often a valuable adjunct to other treatment, and is especially suitable when combined with bromides. In the nerve-symptoms which commonly occur in women at the climacteric period, including restlessness, anxiety, fluttering and sinking at the epigastrium, giddiness, clavus, and sometimes menorrhagia, the perchloride, with or without bromide, relieves much.

Dipsomania.—Morbid craving for drink, and alcoholic insomnia, have been controlled by drachm doses of tincture of iron when many other remedies have failed (Med. Times, i., 1875). The sulphate has also given relief in such cases, especially when combined with aromatics.

Neuralgia.—Before the introduction of many modern remedies for neuralgia, large doses of the carbonate or oxide of iron were much relied upon, and when there is a chlorotic anæmic condition of system they are of service. I should not myself consider iron a remedy for "idiopathic neuralgia," but some observers have attributed to it almost a specific power, especially in neuralgiæ of the fifth nerve: thus, Mr. Hutchinson recommends it in "prosopalgia," and according to Schobelt, the phosphate of iron acts well in neuralgia of the teeth: the citrate of iron and quinine is a very good form when the remedy has to be long continued.

When *neuralgia of the stomach* occurs in anæmic or chlorotic patients, who complain of cramping pain and distension, accompanied with nausea and vomiting of mucus and water, principally before breakfast, and of frequent acid and insipid eructations after meals,—iron is useful, especially when the neuralgia depends on loss of blood or on protracted diarrhœa; I have notes of many such cases cured by it.

Chorea.—When this disorder is dependent upon anæmia,

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iron is clearly indicated, and may prove of great service, as it did in the hands of Elliotson, who used large doses of oxide (Med. Times, i., 1869, p. 136). Sir T. Watson recommends the carbonate. Many cases occur about the time of commencing puberty, and others evince obscure rheumatic symptoms: and in these also iron is useful, but it often acts better when taken in conjunction with arsenic.

Epilepsy.—Ferruginous medicines were at one time esteemed in the treatment of epilepsy or of attacks resembling it, but as diagnosis became more exact, and as more reliable remedies were discovered, iron passed out of use. Brown-Séquard taught that although it might improve the blood-condition, it tended to aggravate the malady itself; and H. Jackson, after much observation, expressed the same opinion. Dr. Gowers, writing more recently, acknowledges that it is sometimes the case, but on the other hand, he has found that iron has a true place in the therapeusis of epilepsy: he has observed benefit from it in cases that are on the borderland between epilepsy and hysteria, and in others when the attacks were limited to the night-time, and in many of these cases the improvement was fairly permanent: he suggests, and I should think very plausibly, that it acts, like other metals (as silver or zinc seems to do in such cases), as a nerve-tonic, rather than simply by hæmatinic properties (Practitioner, October, 1877). Fabre has published a thesis showing the value of the medicine ("Fer contre l'Epilepsie, Paris, 1853). On the whole, we may conclude that iron has been unduly discredited in epileptic or epileptiform conditions. I think that when it arises from onanism, or when a patient is anæmic, it should be used, but generally in combination with bromides.

Constitutional Syphilis.—This malady, like all others in which a poisonous material circulates in the blood, much impairs the condition of that fluid, rendering the corpuscles fewer, smaller, and paler; and in such cases, iron becomes very serviceable, though it will not take the place of more special remedies for the principal disease. Ricord recommended the potassio-tartrate even in primary syphilis, and especially for phagedænic ulceration in debilitated subjects: the theory sustained in opposition to him by certain French writers, that iron aids the

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development of the malady, is not tenable. The iodide of iron I have found very useful in the later stages of syphilis in cachectic subjects.

Struma—Rachitis.—In the different forms of disease included under these headings, and characterized by enlarged or suppurating glands, irritable mucous membranes, caries, and swelling of knee and elbow-joints, emaciation, etc., iron, although much lauded by Hufeland, is not so serviceable when given alone as are certain alteratives—iodine, lime, etc.—but when combined with such remedies it is of great value for the cachexia, anæmia, and torpor of the blood-forming glands, which are usual accompaniments; I have, indeed, found the iodide of iron to be an excellent remedy for most affections of a scrofulous type. The perchloride, as already mentioned, is a good external application for discharging glands. The vinum ferri, or an alkaline citrate with aromatics, is very useful in the *mucous diarrhœa* of rachitic children.

Worms.—The astringent tonic effect of perchloride on the gastro-intestinal mucous membrane, renders it a good adjunct to purgative treatment for these parasites, and a useful prophylactic. When diluted, it may be injected into the rectum for destroying ascarides: I generally use about 1 dr. of the liquor in 4 oz. of infusion of quassia: a stronger solution is liable to cause unnecessary pain.

PREPARATIONS AND DOSE.—Iron preparations, especially the liquid astringent forms, discolour the teeth and stain the tongue black—they should be taken through a glass tube: glycerine lessens the rough astringent taste, and a gargle of milk will relieve it (Guibout). A lotion of quadroxalate of potash (½ dr. in ½ pint of rose-water) will remove the black staining.

Mistura ferri aromatica (made with iron wire, cinchona, calumba, and aromatics): dose, 1 to 2 fl. oz. *Vinum ferri* (made with iron wire and sherry): dose, 1 to 2 fl. dr. and upwards. *Ferrum redactum:* dose, 2 to 6 gr. for adults; ¼ to 1 gr. for children. *Trochisci ferri redacti:* each lozenge contains a grain of reduced iron. Reduced iron may be taken with advantage during a meal, the powder being mixed up with the food.

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Ferri oxidum magneticum: dose, 3 to 5 gr. or more. *Ferri peroxidum hydratum:* dose, 10 to 60 gr. or more in treacle or honey. *Emplastrum ferri—Chalybeate plaster* (contains hydrated peroxide of iron, Burgundy pitch, and lead plaster). *Ferri peroxidum humidum:* dose, 2 to 4 dr.

Ferri carbonas saccharata: dose, 5 to 20 gr. or more. *Mistura ferri composita* (contains sulphate of iron, carbonate of potash, nutmeg, sugar, and rose-water): dose, 1 to 2 fl. oz. *Pilula ferri carbonatis* (contains saccharated carbonate of iron and confection of roses): dose, 5 to 20 gr. or more.

Ferri iodidum: dose, 1 to 5 gr. or more. *Syrupus ferri iodidi* (contains iodine 2 parts, iron 1 part, with sugar and water): dose, 20 to 60 min: each fluid drachm of the syrup contains nearly four grains and a half of iodide of iron. *Pilula ferri iodidi:* dose, 3½ to 8 gr. or more; one grain of iodide of iron is contained in about 3½ gr. of the pill.

Ferri sulphas: dose, 3 to 5 gr: the "Pilules de Blaud" contain carbonate of potash with sulphate of iron. *Ferri sulphas exsiccata:* dose, ½ to 3 gr. or more (3 gr. with 2 of manna make a good pill). *Ferri sulphas granulata:* dose, 3 to 5 gr.

Ferri arsenias: dose, $\frac{1}{60}$ gradually increased to $\frac{1}{6}$ gr. in pill. *Ferri phosphas:* dose, 5 to 10 gr. *Syrupus ferri phosphatis:* dose, 1 dr. and upwards (contains soda and phosphoric acid with 1 gr. of the iron salt in each fl. dr.; is colourless when fresh).

Liquor ferri perchloridi fortior: dose, 3 to 10 min. *Liquor ferri perchloridi*[1] (contains 1 part of the last-mentioned to 3 of distilled water, sp. gr. ·995): dose, 10 to 30 min. or more. *Tinctura ferri perchloridi* (contains 1 part of the stronger solution to 3 of rectified spirit, sp. gr. ·995): dose, 10 to 30 min. or more. *Ferri pernitratis liquor:* dose, 30 to 60 min. *Ferri persulphatis liquor* (chiefly used in preparing other ferruginous salts).

[1] The tincture of perchloride often becomes turbid, which is due to it not containing sufficient chlorine, part of this gas being driven off by the long process of evaporation which is required in order to drive off nitric acid; the quantity of acid ordered in B.P. is 25 per cent. over the quantity required by chemical calculation, and Schacht finds that by using less (20 per cent. less) he obtains a preparation having less hyponitrous ether, and which keeps better (Pharm. Journ., Sept., 1872). The U.S. Pharmacopœia specially provides for the development of muriatic ether in the tincture.

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Ferri et ammoniæ citras: dose, 5 to 10 gr. or more. *Vinum ferri citratis* (prepared with orange wine): dose, 1 to 4 dr. *Ferrum tartaratum:* dose, 5 to 20 gr. *Ferri et quiniæ citras:* dose, 5 to 20 gr. *Tinctura ferri acetatis:* dose, 5 to 30 min.

The non-officinal preparations are very numerous, and include the following:—

Preparations of Tisy (French): these are all proto-salts, and are sent out in capsules—as of Fer ioduré, etc.; analysis shows the quantity contained in each capsule to be very small, and not constant (Practitioner, vol. vii.).

Preparations of Creuse (American): these are double salts, such as a phosphate with ammonio-citrate—non-astringent: he has also a tasteless iodide and chloride (Pharm. Journ., May, 1873, and Feb., 1874).

Preparations of Robiquet (French): these are double salts, as a citro-ammoniacal phosphate; they are not definite in composition. *Preparation of Béchamp* (French): this is a peroxy-chloride, obtained by treating neutral perchloride with a varying quantity of peroxide; it is tasteless, not caustic or irritant, but hæmostatic (Med. Record, 1874, p. 795). *The preparations of Lebarqui, Bravais, Squire, Chateaud, and Manghan* are different forms of oxide—"dialysed," "soluble," colloid. *Van den Corput's preparation* is a double citrate of iron and magnesia (Belgian): that of *Saquet* is a pyrophosphate with soda, ammonia, and malt extract. *Lightfoot's solution* is said to be a magnetic phosphate.

Besides these, we have in more common use—*Bromide of iron:* dose, 1 to 5 gr. *Pyrophosphate of iron:* dose, 5 to 10 gr. *Hypophosphite of iron syrup:* dose, 1 dr. (Pharm. Journ., v., vii.). *Parrish's syrup of phosphates* (compound), containing in each drachm 1 gr. phosphate of iron with soda and potash; *Dr. Frederick Churchill's syrup* (*v.* B. M. J., March, 1880); *Beef and iron wine* (Burroughs); *Monsel's solution* (liq. ferri subsulphatis); and many others.

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HYDRARGYRUM—MERCURY—QUICKSILVER,
Hg, = 200.

Mercury is most frequently found in combination with sulphur, as native sulphide or cinnabar, in mines in Almaden, Ydria, China, Peru, Japan, and California. It is obtained from the ore by fusion with lime, which combines with the sulphur, while the mercury distils over. It occurs, also, as a natural amalgam with silver—"argental mercury"—combined with chlorine in small grey crystals, known as "horn mercury;" also more rarely as an iodide, and sometimes in a pure state—"virgin mercury."

CHARACTERS AND TESTS.—Mercury is a silvery-white metal, with bluish lustre, and is fluid at ordinary temperatures. When pure, it has neither taste nor smell; it readily oxidizes on exposure to the air, but does not tarnish. Should tarnishing occur, it implies the presence of other metals, as lead, zinc, or bismuth; it is susceptible of such division, that it may be squeezed in minute globules through chamois leather. On agitation with alcohol, ether, or turpentine, or on trituration with sulphur or unctuous substances, it loses its fluid character. With other metals, and even with hydrogen, it forms soft compounds termed *amalgams*, and a mere trace of it will leave a white stain on silver or gold. It has a sp. gr. of 13·59, which is exceeded only by that of gold and platinum, is slightly volatile at ordinary temperatures, boils at 662° F., and freezes at 39° F., becoming crystalline, tough, malleable, and sonorous. Its specific heat is low, but it is a good conductor, and has a regular rate of expansion and contraction, hence it is well suited for thermometric and barometric purposes: from its power of combining readily with silver and gold, and yet afterwards quickly volatilizing on being heated, it is valuable in the arts of gilding and silvering, and alloyed with tinfoil it forms the reflecting surface of mirrors.

Hydrochloric acid has no action on mercury, and hence the chlorides cannot be prepared in a direct manner. Sulphuric acid, when boiling, and nitric acid, whether cold or hot, form respec-

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tively salts of different degrees of saturation—*proto-* or *sub-salts* which are known as *mercurous*, and *per-salts*, known as *mercuric*, and which have much more active powers than the former.

The per-salts of mercury are many of them (as the perchloride and red iodide) soluble in ether when the sub-salts are not, so that by this agent they may be separated from each other.

If any salt of mercury be heated in a test tube with sodic carbonate, the pure metal will sublime, and it may be obtained from its various combinations by distillation. With sulphuretted hydrogen in excess, mercurial compounds give a black precipitate of sulphide; but the best general test is the deposition of metallic mercury upon bright copper. It may be applied by heating any mercurial salt with a strip of copper and a few drops of hydrochloric acid, and if the copper be afterwards heated, small globules of quicksilver may be obtained as a sublimate.

COMPOUNDS OF MERCURY.

HYDRARGYRI SUBCHLORIDUM—CALOMELAS—MERCURIUS DULCIS—SUBCHLORIDE OF MERCURY, OR MERCUROUS CHLORIDE—CALOMEL, Hg_2Cl_2, = 471.

PREPARATION.—(1) Ten parts of sulphate of mercury are triturated with seven of metallic mercury and a little water, so that a subsulphate is formed—thus

$$HgSO_4 + Hg = Hg_2SO_4.$$

(2) Chloride of sodium is then added with trituration, the mixture is heated, and the subchloride of mercury sublimes as vapour, while sulphate of sodium is left—thus

$$Hg_2SO_4 + 2NaCl = Na_2SO_4 + Hg_2Cl_2.$$

A large condensing chamber is required in order to obtain a *fine* powder, and this is washed with hot water in order to remove any perchloride that may be formed.

CHARACTERS AND TESTS.—Calomel usually occurs as a heavy, dull, white powder, which is rendered yellow by trituration or by gentle heat: if sublimed in a small chamber, fibrous crystalline lumps are produced. The sp. gr. is 7·2. It has no taste, and hence its name of mercurius dulcis. It is not acted upon by hot water, ether, alcohol, or dilute acids, but potash or soda decomposes it with precipitation of the black oxide of mercury. Prussic acid also turns calomel black by

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causing the separation of metallic mercury. Pure calomel is entirely volatilized by heat, and warm ether shaken with it should leave no residue on evaporation (showing the absence of corrosive sublimate).

HYDRARGYRI PERCHLORIDUM — PERCHLORIDE OF MERCURY—CORROSIVE SUBLIMATE, $HgCl_2$, = 271.

PREPARATION.—By subliming dry mercuric sulphate with four-fifths of its weight of dried sodium chloride, 2 or 3 per cent. of oxide of manganese being previously added to the mixture. The reaction is as follows:—

$$HgSO_4 + 2NaCl = HgCl_2 + Na_2SO_4.$$

Sulphate of soda being left, and corrosive sublimate condensing in the cooler part of the subliming apparatus. It will be noticed that the manganese has no share in the decomposition; it is introduced in order that it may set free from the excess of sodic chloride some free chlorine to combine with any calomel that may be formed, and convert it into corrosive sublimate: calomel would be formed if the mercuric sulphate contained any mercurous salt, as it is apt to do. "The fumes are extremely acrid and poisonous" (Miller).

CHARACTERS AND TESTS.—Corrosive sublimate occurs in white crystalline heavy masses—sp. gr. 5·2—it is entirely volatilized by heat, is soluble in 16 parts of cold and 3 of boiling water, soluble also in alcohol, and still more so in ether. The strong mineral acids dissolve it without decomposition. Alkaline chlorides render it more soluble in water, and hence ammonium chloride is introduced into the officinal solution of the sublimate, and it forms with it a double salt (sal-alembroth). A simple solution in water readily decomposes, calomel being precipitated, and if exposed to light and to contact with organic substances, metallic mercury separates. Ammonia gives a white precipitate of ammonio-chloride, potassic iodide produces the red iodide, potash a precipitate of the yellow oxide, and nitrate of silver a curdy white silver chloride. Albumen also combines directly with corrosive sublimate, and precipitates its solutions.

Liquor Hydrargyri Perchloridi—Solution of Perchloride of Mercury (*v.* p. 672).

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HYDRARGYRUM AMMONIATUM—AMMONIATED MERCURY—WHITE PRECIPITATE, NH_2HgCl, = 251·5.

PREPARATION.—By adding solution of corrosive sublimate to ammonia, chloride of ammonium is formed, and an ammonio-chloride of mercury precipitated—

$$HgCl_2 + 2NH_3 = NH_2HgCl + NH_4Cl.$$

The ammonium salt is removed by washing, after filtration.

CHARACTERS AND TESTS.—This compound occurs as a heavy white powder, or in small cones marked by the linen filters: it has a metallic taste; no odour; is insoluble in cold water, alcohol, and ether; soluble in warm acids; decomposed by caustic potash, evolving ammonia, whilst yellow oxide of mercury is precipitated. Boiled with chloride of tin it gives a precipitate first grey and then black, from the presence first of subchloride and metallic mercury, and next of the metal wholly; this has been called the *magpie* test. "Chlorine and bromine both act violently on white precipitate, forming mercuric chloride or bromide, the action in many cases being attended with explosion. With iodine, an explosion almost invariably takes place after a few minutes: it would appear that iodide of nitrogen is formed" (Miller's Elements of Chemistry, 1878).

HYDRARGYRI IODIDUM VIRIDE—GREEN IODIDE OF MERCURY, Hg_2I_2, = 654.

PREPARATION.—By triturating together mercury and iodine in proper atomic proportions: some rectified spirit is added in order to dissolve the iodine, and to lessen, by evaporation, the heat evolved in the process.

CHARACTERS AND TESTS.—The pure mercurous iodide is a yellow powder, but according to the mode of preparation, or degree of exposure to light, becomes greenish, and olive-coloured or even black; it is insoluble in water or ether; entirely volatilized when rapidly heated, but if warmed slowly in a test tube, it yields a yellow sublimate (pure mercurous iodide), metallic mercury being left: the yellow sublimate turns red on friction.

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HYDRARGYRI IODIDUM RUBRUM — RED IODIDE OF MERCURY, HgI_2, = 454.

PREPARATION.—By mixing together boiling solutions of iodide of potassium and corrosive sublimate: double decomposition ensues, and the red iodide is precipitated.

$$HgCl_2 + 2KI = 2KCl + HgI_2.$$

CHARACTERS AND TESTS.—A crystalline red powder, which becomes yellow when gently heated, and again red upon friction or after cooling: this change in colour is due to a change in crystalline form, the yellow crystals being rhomboidal, the red, octahedral prisms. The salt is insoluble in water, soluble in ether and solutions of iodide of potassium. The presence of iodine may be verified by starch producing a blue colour in a solution which has been digested with soda and acidified with nitric acid.

HYDRARGYRI OXIDUM FLAVUM — YELLOW OXIDE OF MERCURY, HgO, = 216.

PREPARATION.—By adding solution of perchloride of mercury to excess of solution of soda: chloride of sodium and water are formed, and the yellow mercuric oxide precipitates.

$$HgCl_2 + 2NaHO = 2NaCl + HgO + H_2O.$$

CHARACTERS AND TESTS.—A smooth yellow heavy powder, becoming grey on exposure to light; it is insoluble in water, readily soluble in acid, entirely volatilized by heat, being resolved into oxygen and mercurial vapour. This oxide is an allotropic form of the red oxide; it is smoother, and combines more readily with certain acids; it is better adapted for ointment used on delicate surfaces, as the eyelids, and is preferred for the preparation of oleates.

HYDRARGYRI OXIDUM RUBRUM—RED OXIDE OF MERCURY—RED PRECIPITATE, HgO, = 216.

PREPARATION.—By triturating and heating nitrate of mercury with an equivalent of metallic mercury: nitrous oxide gas is given off.

$$Hg\ 2NO_3 + Hg = 2HgO + 2NO_2.$$

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CHARACTERS AND TESTS.—An orange-red crystalline powder, almost insoluble in water, soluble in acids, the solution giving a yellow precipitate with caustic potash in excess, and a white one with ammonia; it is wholly volatilized by a heat below redness, and was the salt from which Priestley first disengaged oxygen (by means of a lens and sun-light).

LIQUOR HYDRARGYRI NITRATIS ACIDUS—ACID SOLUTION OF NITRATE OF MERCURY, $Hg\,2NO_3$, = 324.

PREPARATION.—By dissolving mercury in cold, slightly-diluted nitric acid, when mercurous nitrate is formed.

$$3Hg + 4HNO_3 = 3HgNO_3 + 2H_2O + NO.$$

By subsequent boiling, this is changed into the mercuric nitrate.

$$3HgNO_3 + 4HNO_3 = 3(Hg\,2NO_3) + 2H_2O + NO.$$

Free nitric acid is also contained in the solution.

CHARACTERS AND TESTS.—A colourless, strongly acid solution, from which excess of caustic potash precipitates the yellow oxide; water also decomposes the solution, precipitating oxynitrates. The presence of nitric acid is shown by the darkening of crystals of ferrous sulphate when introduced.

HYDRARGYRI SULPHURETUM—SULPHURET OF MERCURY—CINNABAR, HgS, = 232 (*not officinal*).

PREPARATION—(L. P.).—By melting together, with proper precautions, equivalents of mercury and sulphur, triturating the mixture, and then subliming.

CHARACTERS AND TESTS.—In dark-scarlet crystalline masses, which, when powdered, become vermilion; volatilizes on heating; on reduction with potash, the metallic mercury separates.

HYDRARGYRI SULPHAS—SULPHATE OF MERCURY, $HgSO_4$, = 296.

PREPARATION.—By heating mercury with sulphuric acid, sulphurous acid gas escapes, and mercuric sulphate and water are formed, as represented in this formula:—

$$Hg + 2H_2SO_4 = HgSO_4 + SO_2 + 2H_2O.$$

The mixture is then evaporated to dryness.

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CHARACTERS.—A heavy white crystalline powder, which is decomposed by water into a soluble acid sulphate and a yellow oxysulphate, known as turpeth mineral.

HYDRARGYRI CYANIDUM—CYANIDE OF MERCURY, $HgCy_2$ (*not officinal*).

PREPARATION.—By dissolving 1 part of ferro-cyanide of potassium in 15 of boiling water, adding 2 parts of mercuric sulphate, heating for ten minutes, filtering, and cooling to crystallization: besides the cyanide, mercury, ferric sulphate, and sulphate of potassium are formed in this process.

CHARACTERS AND TESTS.—Rectangular prisms, sometimes transparent, generally opaque and white, taste metallic. Is stable in air, soluble in water, sparingly so in alcohol.

ABSORPTION AND ELIMINATION.—*Metallic Mercury.*—The question whether mercury can be absorbed in its *metallic* state, either by the skin or the digestive tract, has scarcely yet passed from the region of debate, and contradictory facts have been alleged concerning it. Von Hasselt found the metal in the blood of mercurialized persons (Stillé), and Colson obtained a deposit of it from a brass plate placed for a time in contact with blood drawn from a patient who had taken the drug (Archives Gén., xii., p. 86). Claude Bernard filled the medullary cavity of a dog's femur with quicksilver, closed the perforation with wax, and allowed the soft parts to heal; three months afterwards most of the metal had disappeared from the bone, and was found in small globules encysted on the surface of the lungs. In another dog the metal was injected into the jugular vein, and twenty-five days afterwards found "divisé à l'infini," in the cardiac tissue under the pericardium, so that it would not remain in the blood, though taken up by it. Oesterlen used mercurial frictions on cats, giving them also internally pills of blue ointment, and he reported the finding of mercurial globules, not only in the skin, but in most of the organs. Overbeck confirmed these results on rabbits (quoted by Stillé), and Blomberg detected mercurial corpuscles in cats to which he had given pills of citrine ointment (Treatise on Absorption of Mercury,

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Helsingfors, 1868). The latter observer used mercurial friction on the arm of a dead body, and found globules in the corium and mucous layers, but not deeper.

Such observations would seem conclusive, but that Bärensprung, Rindfleisch, and others find it impossible to verify them: they have made the frictions and given the pills, but they cannot find the metal in the blood, nor yet in the corium. Autenrieth could find no amalgam on plates of gold introduced into the subcutaneous tissue under the place of friction, and Gubler and Neumann, whilst they recognized the metal in the sweat-glands and hair-follicles, could trace it no further. Rindfleisch, it is true, found mercury once in mesenteric glands after giving mercurial pills, but there were ulcerations in the intestinal mucous coat which might have permitted the passage of the metallic globules (Archiv für Dermatol., iii., 1870). The most recent observations are those of Fleischer, who concludes from numerous experiments, that "frictions with mercurial ointment cause the penetration of metallic particles into the superficial layers of epidermis, but not deeper:" and a consideration of the whole evidence warrants this negative conclusion, that although metallic mercury, when administered by the mouth in substance, or actually placed within the tissues, may circulate and be deposited, it does not seem to be altered or absorbed in the ordinary sense, and when applied by friction it usually does not pass either into the deeper tissues or into the blood.

The physiological effects of mercurial frictions must be connected, therefore, with its absorption in some other form: either mercurial vapour is inhaled during the process, or a sebacic oxide of mercury enters through the skin. As to the former point, we know that sometimes salivation has occurred in a wife, six hours after a friction made by the husband upon himself only, both living in rather a small room (Samelsohn, quoted by Hallopeau); and additional evidence in favour of such an effect is furnished by the delicate observations of Merget. He demonstrated that mercury volatilized at all temperatures, and by means of iridium-paper (which showed a dark stain on contact with the vapour), he proved its presence on the hands or other parts of the body of persons who had spent only a few hours in

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a workshop where it had been used (Comptes Rendues, Dec., 1871). That the mercurial vapour is not absorbed *only* by the lungs is evident from a carefully devised experiment by Fleischer (Erlangen): he caused frictions to be made upon an arm whilst the patient—with face covered by a mask—breathed only external air; the limb was then carefully wrapped in wool and oiled silk for sixty hours, and during that time the presence of mercury (in very small quantity) was verified in the urine.

We may state then that mercurial *vapour* is absorbed, not only by the lungs but also by the skin, and indeed the results of ordinary fumigations—when the head is external to the apparatus—would be sufficient to prove this. Gubler holds that the sweat-glands are the active agents in this absorption, and Röhrig admits that mercury in vapour can pass through the epidermis (Stricker's Jahrb, ii., 1873). It is probable also that some may be absorbed as oxide in combination with fatty acids (sebacic), or acids contained in the perspiration (Christison). Bärensprung and others have proved the presence of such oxide in "blue ointment;" Nevins calculated it at 1 part in 100, and Voit, analysing portions of skin which had been rubbed with it, found the oxide constantly present. A soluble double salt may be formed with the chlorides of the perspiration (Müller), and if mercurial oxides be given internally, Voit argues that the chlorides of the blood can change suboxide into calomel and peroxide into perchloride, which salts then combine with sodium chloride and albumen.

Metallic mercury, *given by the mouth*, usually passes off unchanged by the bowel; in the rare cases where it has given rise to constitutional effects, a portion has probably been oxidized or changed into sublimate. In the very finely divided form, when the metal is "extinguished" by continued friction with chalk (grey powder), or with confection of roses (blue pill), Rabuteau thinks it may be directly absorbed from the intestine, but no doubt some oxidation occurs during trituration, and the oxide would be soluble more readily in the acid of the gastric juice: mercury in a volatile form would also be disengaged from such compounds as readily within the body as without, at the same temperature. Mercurial ointment or pill, introduced as a suppository into the rectum, produces physiological effects

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perhaps more quickly than by the stomach. In the various trades which require the handling of quicksilver—such as barometer- and mirror-making, gilding, and skin-dressing, and again, in miners at Almaden and elsewhere—the physiological effects produced are mainly traceable to inhalation of the vapour.

Calomel.—Calomel being not only insoluble, like metallic mercury, in ordinary liquids, but being also non-volatile, there has been still more speculation as to how it could reach the current of the circulation.

According to the classic theory of Mialhe, it becomes, like other mercurial compounds, changed more or less into the soluble *perchloride* by the action of the gastric fluids, and is absorbed only to the extent of such change. Mialhe argued from the results obtained by heating together calomel and ammonium chloride in a test tube, but Buchheim and others failed to verify any formation of perchloride in such a mixture at the *temperature of the body*. Rutherford, experimenting more recently, digested 5 gr. of pure calomel in distilled water, with ·02 per cent. of free hydrochloric acid—(the same proportion as in gastric juice)—at 100° F. for seventeen hours, and obtained $\frac{1}{15}$ gr. of perchloride, but it is unlikely that even so much as this would be formed in the stomach; and the action of calomel so far differs from that of corrosive sublimate as to render it, clinically speaking, improbable, that it only depends upon some formation of the latter. Rabuteau, however, maintains that calomel does become changed into perchloride and metallic mercury; also that this perchloride combining with soda salts forms chloride of sodium, and sets free more of the metal,—that under the influence of such changes the compounds are absorbed,—acids and alkalies being afterwards eliminated, and the metallic mercury in part deposited. In this view, though complex, there seems some analogy with what is known of the behaviour of salts of gold, silver, and some other metals, and calomel certainly resembles in action preparations of metallic mercury,—otherwise we have no proofs of such direct absorption of it, but rather the reverse.

Various observers have directed attention to the possibility of calomel being rendered soluble in other combinations, *e.g.*, with

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albumen (Buchheim), or as a double salt formed with chlorides of the blood (Graham). Headland pointed out that *bile* exerts some solvent power on calomel (Lancet, i., 1858), and Gubler asserts that an excess of various organic materials—*albumen*, *mucus*, *epithelium*—acts similarly; some limit, however, must be placed to this observation, for the excess of mucin in the stomach of a dog entirely prevented the absorption of calomel that had been injected into the stomach (Rutherford, Exper. 38). An experiment of Tuson's is more to the point: he placed in one vessel calomel with dilute hydrochloric acid, and in another the same mixture with a proportion of *pepsine*: after digestion for an equal number of hours sulphuretted hydrogen was passed into the solutions and produced a black precipitate in that with pepsine, but none in the other, proving clearly the effect of the organic substance in promoting the solution of the calomel (Med. Times, i., 1872, p. 518). Jeannel pointed out the importance of *fatty* matters for the solution of calomel: in the presence of an alkaline carbonate, it is readily decomposed with precipitation of grey oxide; of this latter a *small* proportion is retained in solution by the water, but if a fatty oil be mixed with the alkaline solution, this proportion is very much increased: the same might readily occur in the intestine (Abstract, Schmidt's Jahrb., 1869, Bd. cxliii., s. 9).

It is quite possible, as H. Wood remarks, that in consequence of the varying composition of the intestinal fluids and the complex chemical relations of calomel, its solution and ultimate absorption may be accomplished in several ways: when more chlorides are present some perchloride may be formed, and when sulphuretted hydrogen is in excess it may produce some amount of soluble sulphide.

Dr. Law, of Dublin, was the first to notice how much the absorption of calomel could be promoted, especially in severe illness, by minute subdivision of the dose, giving, *e.g.*, $\frac{1}{12}$ gr. every hour (Dub. Quart. Journ., xiv., p. 393). Trousseau amply corroborated this observation, and it is, *à priori*, reasonable, for the smaller quantities more readily come into contact with the intestinal fluids to form the double salts or soluble compounds described.

Bellini indicated a difference in the mode of absorption of

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calomel according to the condition of the stomach: thus, when taken fasting, only a small amount was at first dissolved, with formation of double chloride of mercury and sodium, and lactate of mercury; more was dissolved in the *intestine*, under the influence of alkaline carbonate, an oxide of mercury being at first formed, and then a double salt; in the large intestine a sulphide was formed (except in the case of infants). Introduced into the stomach *during digestion*, it was wholly, or almost wholly, decomposed under the action of *proteinous* substances, metallic mercury being formed and a soluble albuminate.

From the cellular tissue some calomel may be absorbed, since constitutional effects have been produced by its *hypodermic* injection when simply suspended in liquid, but the major part remains unabsorbed, and frequently causes abscess.

Corrosive Sublimate.—The absorption of corrosive sublimate may be realized without much difficulty, because it is soluble in ordinary fluids: an albuminate of mercury may form in the stomach, but is probably not absorbed as such: the formation of a double salt with sodium is more likely, and the same occurs with iodides and bromides of mercury: saline or albuminous solutions of perchloride and aqueous solutions of cyanide are also readily absorbed from the cellular tissue.

The chlorides and iodides may also be absorbed from blistered surfaces (*endermic* method), and probably then also, double salts with albuminous and alkaline constituents of the serum are formed.

Elimination. — Although we cannot state positively the form in which mercury circulates or is deposited within the system, whether in a volatile form at first, or as very finely divided metal, or oxide, or as an albuminate, or (which is more probable) as a double chloride with soda or ammonium and albumen, yet we can be satisfied of its detection under certain circumstances, in every organ, and in every secretion. With the *blood* it seems so closely associated, that destructive distillation is usually required for its detection, and in the *milk*, and even in the *urine*, there has been difficulty in finding it, so that some observers have reported against its presence (Köhler, Practitioner, vol. xvii., Cullerier, Brit. and For. Rev., ii., 1852), but the more modern researches of Personne, Binz, Hamburger,

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and others, can leave no reasonable doubt on the subject. Heller detected mercury in the fœtus borne by a salivated mother, and in the urine of an infant whose nurse was taking calomel. Sometimes, however, it may not be discovered after inunction, though readily after the use of mercurial suppositories (Prag. Med. Woch., iv., 1877, Lancet, ii., 1877). (The modern and accurate method of detecting mercury is by electrolysis.)

The question of its *elimination by the milk* is one of much importance, for large establishments have been formed in Paris for the treatment of syphilitic infants especially, through the milk of nurses or of goats that have taken mercury: such treatment is constantly adopted with good result, and there is abundant clinical evidence of its value. With regard to the time during which mercury remains in the system, it is ascertained that of a single dose elimination is rapid, and is apparently completed within twenty-four hours; for $\frac{1}{6}$ gr. of perchloride having been taken, the urine contained traces for that period, but not afterwards; and ·075 gramme (about 1 gr.) having been injected under the skin of a rabbit, none could be discovered in any part of the body four days afterwards (Mayençon and Bergeret, Robin's Journ. Anat., No. 1, Lancet, i., 1873). M. Byasson injected $\frac{1}{3}$ gr. of sublimate under his own skin, and found mercury in the urine two hours afterwards, and at the end of four hours in the saliva, but after twenty-four hours he detected no more. If treatment have been continued for some time, mercury may be found in the urine for several days afterwards; thus, in the urine of two patients who took $\frac{1}{6}$ gr. daily for ten to twelve days, the drug was found for four or five days after treatment had been omitted.

During a mercurial course, the greater part of the drug is eliminated almost as soon as taken, but some remains in the tissues and passes out insensibly; and when the doses have been large and long-continued, some may be retained in the organism for months or even for years. It is, in fact, impossible to recognize exactly when its elimination is complete, though it is probably not so prolonged as that of gold, lead, or silver (Husemann). Years after its prolonged administration, unusual perspirations may develop dark mercurial stains on the linen, or a white coating be given to a piece of copper on handling it (W. Pope,

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quoted by Stillé). Salivation may reappear without apparent cause (unless a chill); sometimes it has been traced to the use of sulphurated mineral waters, and occurred in one patient ten years after taking the medicine (Hartung, quoted by Hallopeau). I have myself seen five patients, while under the influence of nitric acid, suffer from salivation and other physiological symptoms of mercury, and none of these had taken that drug for over eighteen months previously: I considered it clearly traceable to the mercury in the system, and not to the acid. The metal has been found in the liver of a workwoman who had not, for twelve months previously, been exposed to mercurial vapours, and in the liver and kidneys of another who died of phthisis six months after leaving her work at a mirror factory (Küssmaul, Gorup Besanez, Wien. Med. Woch., 1862).

Melsens pointed out (1844) that iodide of potassium favoured the elimination of mercury as well as of lead, and in many cases it has been found that elimination, which had ceased, has been renewed under the influence of the iodide; yet this influence is not always sufficient to complete the process, for Küssmaul found a quantity of mercury in the viscera of a patient who had taken none for four months, and who, in the course of a month, had taken 2 oz. of the iodide.

Riederer has made experiments to ascertain the *quantity* of mercury that may be found in different organs or secretions: of about 10 gr. of calomel given to a dog in thirty-one days, he recovered four-fifths—the largest proportion from the fæces, the next from the urine, the liver, the thoracic viscera and brain, and the least from the muscles (quoted by Hallopeau, p. 58). Other observers agree that on section of an animal subjected to the action of mercury, the largest amounts are found in the liver and kidneys (and not in consequence of their containing more blood than other viscera, for the blood contained a much less proportion of the drug); it must therefore be considered to have a special determination to the liver and kidneys, and it is eliminated mainly by the bile and the urine; in this respect it resembles other metals.

PHYSIOLOGICAL ACTION.—*External.*—The local action of mercury varies according as to whether the metal itself is used, or

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one of its soluble or insoluble compounds, and of course according to the strength of the preparation; and on account of the volatility and the ready absorption of the drug, its local use often induces its systemic effects.

Metallic mercury produces upon the skin no other local effect than a sense of coldness. Mercurial ointment applied by friction is usually well borne, but sometimes excites a red or vesicular eruption (mercurial eczema), more or less intense; ointment of the red oxide is painful to sensitive parts, and that of the red iodide may irritate very severely, even to vesication: if not perfectly fresh an additional source of irritation is found in rancid lard: good calomel ointment is rather soothing than otherwise.

A strength of 2 gr. of corrosive sublimate in the ounce of liquid suffices to destroy parasitic life; a stronger lotion irritates. Cloquet, the distinguished anatomist, suffered from severe local and general symptoms after handling some preparations steeped in a strong solution. A proportion of 10 gr. to the drachm of alcohol vesicates, and when applied to the scalp has caused death in a child (Lancet, ii., 1871). In two other children, the use to the scalp of an ointment containing 120 gr. to the ounce of tallow also caused death (Dub. Journ., Aug., 1854). The solution of the metal in nitric acid (liquor hydrargyri nitratis acidus) is a powerful and painful caustic, and its application has sometimes, though not frequently, been followed by severe general symptoms: it combines with albumen and fibrine, producing a white eschar.

On the mucous membrane of the intestinal tract mercurial compounds may exert a *local* action of the same nature as upon the skin. Quicksilver, in doses of ½ oz. or more, will usually pass through the intestine by its mechanical weight, and unaltered; sometimes it has caused perforation.

PHYSIOLOGICAL ACTION.—*Internal.*—In studying the action of this medicine, it is more than usually important to distinguish between the effects of *small* and of *large* doses. Modern observation shows us that the former are rather of tonic and constructive character, whilst older records have told us only too well the fatally destructive results of the "heroic" adminis-

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tration of the drug. I do not mean simply that one grain, *e.g.*, of calomel has a different effect from twenty: we must estimate the dose rather by what is absorbed of it, and by the results shown, especially by the state of the mouth and the secretions. Practically we can either give the medicine so as to cure without marked effect upon these, or so as to produce only moderate effects, and it is this "slight mercurialization" which requires to be distinguished from the severe form which should be called rather mercurial poisoning, and is accompanied with stomatitis, salivation, diarrhœa, cachexia, etc. A similar difference of degree exists, of course, in the action of all powerful medicines, but it requires more attention in the present instance, because our predecessors thought to give benefit only by what we consider a poisonous action of the drug, and it consequently fell into undeserved discredit. There is, further, a chronic form of mercurial poisoning which may still be met with in various trades, and this differs in some respects from any condition produced by modern medication.

Circulatory System.—Recent observations as to the action of mercury on the blood illustrate well its different effects, since they show that, in quite small doses, it increases the number of red corpuscles, and improves the blood-condition. Grassi proved this by analyses, and Wilbouchewitz counted carefully under the microscope the average number contained in a millimetre-cube, and his patients (ten in number) then took either $\frac{3}{4}$ gr. of sublimate daily, or $\frac{1}{6}$ gr. of proto-iodide: during the first fortnight of treatment the increase of corpuscles amounted to nearly one million.

These patients were syphilitic, and probably the anæmia of their malady was benefited by the antidotal action of the mercury, for the remedy being continued beyond a certain time (and thus allowed to accumulate in the blood), the red globules diminished in number, so that, by the end of the second fortnight, they counted the same as before any treatment. Mercury being then omitted altogether, the corpuscles increased again within a week's time. The inference is clear,—*too much* of the drug impaired the blood-condition, but a *little* improved it. When it was omitted, and when, after a few days' time, only a small proportion remained in the blood, the original im-

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provement was again observed: the white globules varied in an inverse ratio (Archives de Physiologie, 1874). Keyes repeated these observations, and concluded that small doses of mercury increase the blood-corpuscles *in all subjects*, whether syphilitic or not; and further, that this increase is not temporary: he has never seen hypoglobulism—*i.e.*, a lessened average number of corpuscles, caused by small doses (Amer. Journ., Jan., 1876). Possibly the difference between these two observers may arise from difference in dosage, Wilbouchewitz giving the rather large quantity of "$\frac{1}{3}$ gr. sublimate daily;" no doubt mercury in any form, continued long enough, and absorbed, will produce a *destructive* effect on the corpuscles, and a condition of "spanæmia." Long ago, Bretonneau and Dumont reported that the blood-clot in mercurialized animals was either absent or was soft and diffluent. Headland's expression is that mercury "disintegrates and decomposes the blood" (Lancet, i., 1858), and Wright's analysis showed it to be more fluid and less coagulable than normal, its albumen, fibrine, and red globules being diminished, and a fœtid, fatty material being formed in it. Gubler has also corroborated this destructive effect, and yet Lemaire and Gelis found "mercurial treatment to increase plasticity of blood." Autenrieth questions the analysis of Wright, and more lately Overbeck found in animals poisoned by mercury the venous blood dark and thick, the arterial blood clear and coagulating well, fibrine increased: probably these results were connected with inflammatory reactions, but if verified, they tell much against any available "aplastic power" of mercury in inflammation; still, the *ultimate* effect of the drug is destructive. Polotebnow, adding mercurial albuminate to the blood of dogs, found the corpuscles rapidly destroyed, with loss of hæmatine and pigment (Schmidt's Jahrb., 1865, 125, 3). Wilbouchewitz, giving calomel to rabbits (and not in large doses), noted a rapid diminution of corpuscles. Trousseau found that leech-bites that had ceased bleeding, bled again in patients submitted to mercurial treatment, but beyond any single facts is the general experience that too much of the drug induces—after a period of malaise, restlessness, and febrile symptoms—a chlorotic pallor of the skin, with signs of enfeebled circulation, distress in breathing, intermittent pulse, and palpi-

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tation; such a condition, when fully developed, is difficult of cure; it may last long, and end fatally.

Fothergill includes mercury amongst his "cardiac depressants," and G. Harley, having injected sublimate into the femoral vein of a dog, found that cardiac paralysis was produced before intestinal contractions ceased (Proc. Roy. Soc., 1864).

Nutrition.—Nutrition is so closely connected with hæmatosis that we shall be prepared for the modern observations that it also may be improved by *small* doses of mercury. Keyes found this to be the case—the *weight* of his subjects increased under their course, and the remedy acted "as a tonic." Hufeland had previously made a similar observation, and Basset, Liégeois, and others corroborate it: the last-named observer considers sublimate in minute doses "comme un réconstituant des plus puissants" (Annales de Dermatol., i., ii., 1870), and M. Clerc reports the same experience (Gaz. de Paris, 1872, p. 481): it has been verified also, independently of syphilis, on animals, and especially rabbits.

On the important question of *urinary excretion* the principal evidence is negative. We need more research in this direction, but so far the evidence does not favour the theory of mercury (in small doses) curing disease by *increase* of tissue-change—that it lowers the temperature in animals (except during the stage of "erethism"), and that it does the same in fever (Wunderlich), I should take as evidence of its *lessening* change, rather than the contrary, as Husemann does. Altogether, at least in the doses under consideration, mercury merits the name of "moderator of nutrition," rather than of alterative (Rabuteau); and in this rôle we can see its analogy with small doses of arsenic, antimony, etc., under which, as is well recognized, weight may be gained, and nutrition improved. Under full or poisonous doses, when the blood-corpuscles are destroyed, the secretions are rendered profuse, and digestion impossible, nutrition is, of course, profoundly impaired, and waste of tissue progresses most rapidly.

Digestive System.—Small (therapeutical) doses of any preparation are usually well borne by the stomach. Rabuteau cites cases where many hundred pilules of proto-iodide have been

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taken in the course of one to three years without any gastric disturbance: yet we must allow for some idiosyncrasy in this respect, and practically we find that those who have resided long in the tropics, and fair, delicate women and chronic dyspeptics are very sensitive. It is not, however, possible to say beforehand what amount of mercury will produce the characteristic effects on any given case—a single friction or a few grains may produce in one patient what many weeks of treatment will not do in another. Single doses of calomel—from 1 to 5, 10, or even more grains—produce thin and "bilious" stools without much griping. If the intestine of an animal be examined after such actions, it will be found reddened, especially in the upper part, and its glands stimulated. As a rule, ordinary care will early detect symptoms of constitutional action in the mouth, such as a sense of heat, metallic taste, sticky coating of the tongue, increased flow of saliva, and perhaps slight tenderness of the gums. On continuance of the medicine, these latter symptoms increase and diarrhœa occurs, with some nausea. The stools, at first feculent, become thin and sometimes papescent with mucus, sometimes yellow, or dark or grass-green (the latter especially in children: they have been compared to "chopped spinach"): sometimes blood appears in the motions, and severe colic and tenesmus occur. The tongue is said to show a greenish coating with two longitudinal red stripes (Traube). In severe cases, when the poisonous action of mercury has been induced, intense stomatitis appears, with swelling of the tongue and gums, membranous deposit, fœtor, loosening of teeth, and severe pain and difficulty in mastication. The salivary glands become enlarged and tender, and a vast amount of secretion pours from the mouth: 10 lbs. of it have been secreted in twenty-four hours: at first viscid as usual, it soon becomes thin and very watery, containing albumen, mucus, and alkaline chloride (Thompson). Children and the aged are seldom salivated—Graves suggests because their salivary glands are "inapt"—diarrhœa or prostration is with them the earliest symptom. Salivation is connected, too, with local causes: it comes on more quickly when the mouth is unclean, and may be almost wholly prevented by great care with the teeth: dental caries will determine it; it is said to commence by the last molar of the

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side on which the patient mostly sleeps (Ricord): also the irritation of a wisdom-tooth, or of a pipe, will influence it.

Such facts have led to the supposition that salivation is only *secondary* to buccal soreness, but this is incorrect: it may be induced by rubbing mercury over the parotid, and *before* any irritation is produced. Ricordi detected the drug in saliva drawn from Steno's duct, by a catheter, in animals, when calomel had been injected beneath the skin, and salivation occurs, as we know, independently of mouth-irritation from the action, *e.g.*, of gold, iodine, various acids, etc., as well as during pregnancy and certain diseases. The safe test of a mercurial salivation is detection of the metal in the secretion. Women seem to be more readily affected in this way than men, and the subjects of granular kidney, of scrofula, and of scorbutus are peculiarly susceptible (Christison and others). It occurs more frequently under fractional (non-purgative) doses of calomel, or inunction of blue ointment, than from fumigation, suppositories, or injections: it is markedly less under the use of sublimate, iodide, or cyanide, than of insoluble preparations, either on account of the smaller dose of the former employed, or of some peculiarity in their elimination. Ulceration, or sloughing of the gums, hæmorrhage, periostitis, and prostration of even fatal character have occasionally followed a profuse salivation, and necrosis, scars, and contractions have accompanied even recovery.

We have seen that a local action, irritant in character, is exerted by most compounds of mercury on the alimentary tract; but H. Wood speaks of calomel as "free from all irritant properties," and Lente argues that large doses (one teaspoonful) act in a sedative manner (New York Journ., 1870, vol. xi.)—this was the argument of Annesley, but it is not a safe one to act upon. The irritation excited by corrosive sublimate in toxic doses is, however, the most severe: there is an acrid taste, and a sense of burning and constriction in the mouth and fauces, with whitening and shrivelling of mucous membrane if the dose be concentrated: vomiting and purging with tenesmus usually occur, with passage of blood, suppression of urine, and general symptoms of gastro-enteritis: after death, signs of inflammation, contraction, or ulceration have been found, especially in the stomach and upper part of the intestine, and that this is not

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merely a local effect is proved by its occurrence when the drug has been administered by the skin. Profound depression is usually a symptom of sublimate poisoning, and is sometimes more marked than pain, vomiting, or purging; salivation is by no means constant in acute cases.

The iodides of mercury act much like corrosive sublimate, the red iodide being more actively irritant than the green one. The red oxide produces similar lesions of the intestinal canal (Orfila); it is not given internally in medical practice, nor is the ammonio-chloride (white precipitate), but in a case when a large quantity of the latter compound caused death, the stomach was found contracted, and its lining membrane ecchymosed (Guy's Reports, 1874). The liquor hydrargyri nitratis has produced intensely severe effects on the intestinal tract, and irritant poisoning has followed the accidental use of the sulphides and the cyanide of mercury.

Glandular System, Liver, etc.—Most of the glandular organs are liable to become congested, and stimulated under the influence of mercury. This has been noted not only of the salivary glands as already described, but also of the pancreas and intestinal glands, the kidneys and the liver, the testis and the lymphatic glands of axilla and groin (C. H. Jones, Med.-Chir. Trans., vol. xxxv., etc.). As illustrating the effect on the pancreas, Dr. Copland recorded a case, where, in addition to salivation, deep-seated epigastric pain set in, with nausea and diarrhœa of thin fluid resembling saliva; after death the gland was found large and congested. Radziejewski found, on analyses of the stools after giving calomel, a large proportion of leucin, tyrosin, and indol (pancreatic secretion), which he did not find after other purgatives (Reichert's Archiv, 1870). That calomel also stimulates the intestinal glands has been demonstrated by Rutherford.

The mode of its action on the liver is still a subject of discussion, and the conclusions of some physiologists on this subject are opposed to those of many practical physicians. Up to a recent period, mercury was universally regarded as a typical "cholagogue," in the sense of its stimulating both the secretion and the excretion of bile, and hence was commonly employed, both in cases of deficient secretion to

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stimulate, and in cases of excessive secretion to "carry off" the excess.

The early experiments of Murray were taken to corroborate the theory of "cholagogue" action, for after giving purgative doses of calomel to dogs, he found increased discharge of bile, mucus, and serum from the bowels (quoted by Morehead, 1841). Buchheim also reported an increase in the amount of bile discharged by dogs with biliary fistulæ. Still more important evidence was furnished by the analyses of Michéa, which were made first upon the normal stools of six healthy subjects without detecting bile; then, with nearly like result, upon the green stools of persons suffering from diarrhœa; then upon the greenish motions which occurred in eight healthy persons after taking calomel, and in all of which bile was clearly detected; and lastly, upon discharges produced by different saline and resinous purgatives, and in which no bile was found (Lancet, i., 1849). Although these observations show an increased *discharge* of bile under calomel it is clear that they do not necessarily prove an increased *secretion* by the liver-cells, and therefore experiments on animals as to this point were undertaken. Kölliker and Müller, after giving calomel to dogs with biliary fistula and collecting the bile discharged, reported contradictory results—the secretion being in one instance increased, whilst in two others it was diminished (1855). Scott, experimenting with large doses of calomel on four dogs (also with fistulæ), recorded diminution of both fluid and solid biliary constituents in all the animals (Beale's Archives, i., 1858). Mosler, with two dogs, obtained a similar result (Virchow's Archiv, xxxii.); and Hughes Bennett, reasoning from the experiments of the Edinburgh committee, announced, as a positive fact, that mercury really *lessened* the biliary secretion in man as well as in animals (1868). The experiments on which this physician founded his important conclusions require a brief consideration: they were made upon forty-one animals, and on account of difficulties in the operations, etc., results considered satisfactory were only obtained in nine instances — in four of these calomel was used: a permanent fistulous opening into the gall-bladder was very carefully effected, and about fourteen days afterwards the bile was collected on a sponge. The first dog, before taking any drug,

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secreted a daily average of 82 gr. bile-fluids, and 5 gr. of bile-solids; after taking 4 to 12 gr. calomel daily, it secreted only a daily total average of 60 gr.; but it must be noted that the animal's condition was much impaired, it took little food, and soon afterwards died. The second dog got smaller doses ($\frac{1}{14}$ gr.) every hour; the general health became affected, and it soon died: the average bile-secretion was about the same, before and after giving the drug. The third dog received some blue pill in addition to the small doses of calomel, and the bile-average was diminished one-half; the animal suffered much. The fourth dog got purgative doses, with an average bile-diminution whilst under their influence; on one day, however, when blue pill was given, the average was increased (B. M. J., i., 1869). Such results scarcely warranted Dr. Bennett's conclusions, which were indeed publicly controverted by Christison, Fraser, and other members of the same committee. Röhrig (of Kreuznach) reported that large doses of calomel slightly increased the bile secretion (Stricker's Jahrb., ii., 1873), but we may take the more recent experiments of Rutherford and Vignal as showing, so far as experimental research can show, that the drug does not really do so. They proved (1) "that doses of 10 gr., 5 gr., or 2 gr., several times repeated, placed (without bile) in the duodenum of a fasting dog, produced a purgative effect varying with the dose, but so far from increasing bile-secretion, usually diminish it; (2) that there is no difference in the result if the calomel be given in 1-gr. dose, several times repeated, mixed with bile and introduced into the duodenum" (B. M. J., ii., 1875–76, Practitioner, Dec., 1879). On the other hand, the same observers found that *corrosive sublimate* in doses of $\frac{1}{8}$ and $\frac{1}{16}$ gr. powerfully stimulated the secretion of bile, whilst it did not stimulate the intestinal glands (B. M. J., ii., 1877). They further instituted experiments which showed that calomel does not become changed into *corrosive sublimate* to any appreciable amount under the influence of the organic secretions. Rutherford himself notes that the experiments referred to do not prove anything as to the action of mercury on the *bile-expelling* apparatus, and we may grant that they are correct without any denial of the clinical fact that a purgative dose of calomel will increase the amount of bile discharged by the bowel; it may do

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this, not necessarily by a previous stimulation of the liver, but either by irritating to unusual contraction the gall-bladder and gall-ducts, or by lessening a congested condition of these parts, through the discharge induced from intestinal glands.

Dr. Lauder Brunton has further pointed out that the clinical fact of calomel relieving "bilious conditions," receives from the experiments of Schiff and Lusana an explanation not at all inconsistent with Rutherford's conclusions (Practitioner, vol. xii.); these experiments go to prove that the liver not only *secretes* bile, but also *excretes* it, separating from the blood a part of that which (normally) circulates in it: for after effecting biliary fistulæ in animals, bile flowed at first freely—afterwards, in much diminished amount, independently of any drugs. This diminution was accounted for by the passing away of bile so soon as formed, and the consequent impossibility of its being reabsorbed from the duodenum into the circulation, to be again excreted, for if *fresh* bile were passed into the blood by intravenous or cutaneous injection, then the amount of excreted bile was again increased. Schiff further showed not only that bile can thus circulate without giving rise to jaundice, but that it probably always does so, passing from the liver to the duodenum, thence into the blood, and so to the liver again, a portion only, more or less changed, passing out by the fæces.

This tallies with the observation of Murchison, that "by increasing the elimination of bile, and lessening the amount circulating in the portal blood, mercury is a true cholagogue, relieving the liver thus, more than by merely stimulating it to increased secretion" (Lancet, i., 1874). The green, liquid, spinach-like stools produced by calomel have been variously attributed to intestinal irritation, to altered hæmatin (Golding Bird, 1845), and to subsulphate of mercury (Thudichum); it is possible that they may contain sometimes mercurial compounds, but they certainly often contain bile. According to Simon's analysis of the fifth stool passed after a large dose of calomel, it was fluid, green, without fæcal odour, of acid reaction, and contained mucus and epithelial cells, fat, cholesterin, bilin, and bile-pigments,—no mercury whatever (Animal Chemistry, vol. ii.).

Genito-Urinary System.—Women affected with mer-

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curialism are liable to abort (Colson, Lizé), yet it is equally proved that syphilitic women should be treated with medicinal doses, for in such doses mercury may save them from abortion (M. F. Weber, 1875). The influence on menstruation is not constant; generally this will be diminished, but sometimes much increased.

Lusana found that mercurialism in fowls prevented the laying of eggs, and Gaspard, that the vapour of quicksilver prevented eggs from coming to maturity.

Small (therapeutical) doses exert no marked effect on the kidneys, but we have seen that the drug is largely eliminated by those organs. Overbeck, indeed, found leucin and results of disintegrated albumen in the urine of animals (Husemann), but E. R. Harvey, experimenting on dogs, found the *quantity* of urine unaffected, the phosphates always diminished, the urea not increased beyond a normal variation (Brit. and For. Rev., i., 1862). Von Böck could find no definite change in the excretion of nitrogen or uric acid (1869). Bouchard reported a diminution of urea, but his patient had uræmia (1874); and more recently, Conty, after observation on twelve syphilitics taking therapeutic doses of proto-iodide, could verify no definite alteration. During pronounced mercurialism albuminuria may occur with or without hæmaturia (Pavy, Overbeck, Küssmaul). After death, congestion and fatty degeneration have been found (Balogh and others); and Ollivier has pointed out the analogy between such conditions and those produced by lead.

The albuminuria does not necessarily imply altered renal structure, it may be dependent only upon general dyscrasia and loading of the blood with organic débris (Gubler), but in severe or prolonged cases, steatosis is very probable. Bouchard has recorded two important illustrations; in one case of acute mercurialism, five days after salivation had commenced, suppression of urine occurred, and on the ninth day the patient died comatose, and a very large amount of urea was found in the blood, almost proving that uræmia was the cause of death. We have not details of the second case, but in both, the Malpighian bodies were found to contain, or to be changed into, mineral matter, proved to be carbonate of lime (Hallopeau, p. 113). This condition is very interesting when compared with Salkowski's

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results in rabbits; he injected fractional doses of sublimate, of iodide, and of calomel, and after death, found constantly lime and soda deposits in the Malpighian bodies; the urine became pale and contained sugar. Cornil also found calcareous deposits, and Kletzinski reported diabetes.

Nervous System.—From the medicinal use of mercury we seldom see definite effects on the nervous system, beyond a temporary malaise, chilliness, depression, or erethism; the severe symptoms of neuralgia, tremor, convulsion, or paralysis are met with only in persons exceptionally, or for a prolonged period, exposed to its action, such as those who work with it and suffer from a "chronic mercurial poisoning." A grain of calomel or blue pill has been taken every night for more than forty years without other than good effects apparently, for one cannot argue much from fatty degeneration at the age of seventy-four (Med. Times, ii., 1867). On the other hand, tremor has developed in one night under the influence of strong mercurial fumes (Christison), but, as a rule, the slow and continued absorption by the skin and the lungs of metallic quicksilver or its vapour is the cause of symptoms such as those we are now considering. Anstie pointed out that sensory nerves were sometimes affected by it, "a selective affinity" being shown for the fifth, whence an attack of severe and persistent facial neuralgia; but severe pain may also affect the head generally, or all the limbs (Lancet, ii., 1872); the pains are usually made worse by warmth; tingling or other alterations of sensibility may be experienced; there may be partial anæsthesia or analgesia which either varies, as in hysterical subjects, or may be permanent; abnormal sensations of cold are also described. Tremor is the most constant symptom of chronic mercurialism: all the workmen in mercurial mines suffer from it, and sometimes it is the only symptom apparent, there being neither salivation nor erethism: it commences usually in the lips and the tongue, and soon affects the upper extremities; it is most marked, like the tremor of sclerosis, under the influence of voluntary movements, or of fatigue; it may exist in all degrees up to severe convulsive movement affecting the whole body (called "calambres" at Almaden): slight cases of tremor are curable in a few weeks; more serious ones last for months or years, and yet the subjects continue to walk and

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to work. The tremors cease during sleep, and also, it is said, during intoxication; this is an interesting fact, as also is the transmission of the malady by inheritance, so that children are born in the state of tremor.

The phenomena of exaggerated action pass, after a time, into those of paralysis, so that one or more muscles may cease to answer properly to the will, though muscular power is retained (as in locomotor ataxy); the extensors are often affected: sometimes the paralysis is temporary, and of hemiplegic character: electro-muscular contractibility is preserved, but atrophy of muscles may occur.

It remains to note the *mental* condition in chronic mercurialism: emotional sensibility is generally heightened, the patient is timid and easily excited, intelligence is weakened, and a delirious condition (like that of delirium tremens) occurs in paroxysms; sleeplessness is marked. We cannot say that true epilepsy is produced, though the convulsive attacks may have been called by that name, but giddiness and noises in the ears, muscæ, nausea, and tendency to fall, constitute a condition resembling at least "petit mal." It is not likely that apoplexy can be directly connected with mercurial poisoning.

With regard to the *pathology* of the nerve-symptoms described, Anstie suggested that the cortical grey matter was mainly affected. Ross, in his able paper, seems to think that an effect on the connective tissue of the nerves would explain it (Practitioner, 1870). Mercury has been found by analysis in the brain, but we can scarcely consider its effects to be directly and locally poisonous to the nerve-cells: we may gain some light from the changes discovered in cases of alcoholic or saturnine saturation of the nervous centres, and those we find to be mainly chronic inflammation and fatty degeneration (Lancereaux, Vulpian).

Cutaneous System.—We have spoken of the local irritation that may be excited by mercurial frictions. There may be merely erythema with much itching, or an eczematous (vesicular) rash, or even erysipelas and gangrene (Stillé). The internal use of mercury may also, exceptionally, give rise to eruptions, of which Bazin has distinguished three forms, "hydrargyria mitis, febrilis, and maligna," showing either a simple efflorescence about the thighs, the scrotum, abdomen, and

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axillæ, or a more intense form with vesicles, or one still more severe with general œdema and purpuric rash. The general symptoms in such cases may be serious: desquamation occurs in the milder forms about the eighth or tenth day; malignant forms (which I have never seen) may give rise to adenitis, abscess, or ulceration. Occasionally, owing to idiosyncrasy, a scarlatinoid rash may be excited by a single dose, as by $\frac{2}{3}$ gr. of proto-iodide in a case recorded by M. Fournier (Hallopeau): one application of acid nitrate produced the same effect, as also did a few Dupuytren's pills ($\frac{1}{6}$ gr. sublimate). If cachectic ulceration be present, the action of mercury is likely to increase it, and ulcerations in the mouth especially may be caused by it: they are more irregular and less indurated than syphilitic ulcers.

In exceptional cases, the secretion of sweat has been increased, it being of a clammy character and fœtid odour: a general brown colour of skin or the occurrence of rupia and ecthyma has been sometimes noted, but it is not true that eruptions really equivalent to syphilitic eruptions are produced by mercury.

The hair and nails are said to have fallen off under its use. The teeth are said to show the effect of the drug, especially when administered in infancy, by a deficiency in the enamel, most marked in the first molars (Hutchinson, Med. Times, ii., 1876, p. 242, Laycock, i., 1862, p. 450); but this is not yet an established fact.

With regard to the tissues of the *eye*, we have evidence that iritis and retinitis may be produced by the continued employment of mercury, but a more usual condition is conjunctivitis, which occurs with the ordinary symptoms, such as suffused redness and injection, smarting, burning, and some excoriation and purulent secretion.

Osseous System.—A form of periostitis occurs sometimes during a course of mercury, and it has been a question whether this is due to the remedy or to the malady (syphilis), for which it is commonly prescribed. Pereira thinks the latter supposition correct, but Graves states that he has seen periostitis occur in patients mercurialized for some other illness, and who had never contracted syphilis, and to this I can add my own testimony, having witnessed such an occurrence several times. The tibia, the bones of the forearm, the clavicle, sternum, and frontal

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bones are those more commonly affected, and the pains, intermittent at first, are increased by warmth, or by changes of temperature, though sometimes relieved by a low temperature. The articular ends of the bones are liable to be affected, and even caries may be produced.

SYNERGISTS.—Agents which fluidify the blood and secretions, such as alkalies, favour a similar action in mercury. Oxygen, dilute acids, and alkaline chlorides favour the transformation and absorption of metallic mercury, and hence assist its action. Bellini, however, concluded that these agents lessened the effect of mercurial chlorides and iodides by preventing the action of carbonated alkalies upon those salts in the intestine, and impairing the formation of double salts: magnesia he found distinctly adjuvant, it giving rise to a double chloride with mercury. Carbonate of soda has been found to increase its purgative effect (Hunt, Brit. and For. Rev., ii., 1852), and rhubarb, colocynth, jalap, or other purgatives are used to aid its action on the liver or intestine.

Alkaline iodides markedly increase the constitutional action of mercury,—Wreden has especially shown this (Central Zeitung, 99, 1874, and B. M. J.). A skin rubbed with *blue ointment*, and then after an interval, and after cleansing, rubbed with *iodine ointment*, becomes much inflamed, evidently from a chemical combination (biniodide of mercury). Milk, bromides, sulphites, and prussic acid, are also said to increase the effect of mercurial compounds (Bellini), and the good effects of mercurial treatment in syphilis are specially aided by the concurrent use of the sulphurous waters of Aix-la-Chapelle (B. M. J., i., 1874, p 108).

ANTAGONISTS AND INCOMPATIBLES.—Sulphur, especially in the form of sulphuretted hydrogen, antagonizes the physiological action of mercurial compounds, whatever their therapeutical relations may be (*see* above). Chlorate of potash controls, to some extent, its salivating powers; *astringents*, such as alum and tannin, lessen fluxes, and tonics and stimulants oppose mercurial cachexia.

Finely-divided iron, or zinc, or gold, acts as a mechanical anti-

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dote in cases of mercurial poisoning (Johnston, Amer. Journ., April, 1863), but albumen is perhaps more efficient: the white of one egg is calculated to form an insoluble compound with 25 centigrammes (about 3½ gr.) of sublimate (Peschier).

Treatment of Mercurial Poisoning (Acute).—By an emetic of ipecacuanha, if necessary, the poison should be as far as possible removed, and then albuminous demulcent drinks freely administered. The white and yolks of raw eggs with milk are very suitable, or gluten may be prepared by washing flour in a muslin bag under a stream of water, or the flour itself may be given in a paste (Tanner). Opium may be required for the pain and purging, and for the mouth-condition, gargles of alum or borax. For salivation sulphur has been strongly commended, and to promote elimination when the acute symptoms have subsided, the iodide of potassium is to be advised. The symptoms of poisoning by corrosive sublimate are sometimes insidious, and after evacuating the stomach a principal indication is to sustain the strength. In a man under Dr. Mackey's observation, who had taken sublimate with suicidal intent and in large quantity, there were, at first, no symptoms, so that doubt was thrown on the history given with him when first brought to the Queen's Hospital. The stomach-pump was used, and for some days afterwards he complained of nothing but slight abdominal pain and weakness. Milk and beef-tea were given,—perhaps not in sufficient quantity,—and stimulants were not ordered: he died in about a week, apparently more from asthenia than from irritant poisoning, but an inflammatory condition of the large intestine was found.

THERAPEUTICAL ACTION.—*External.*—The destructive effect of mercurial compounds upon the lower forms of animal and vegetable life is extensively utilized in the treatment of *parasitic diseases.*

Phtheiriasis.—When pediculi infest the head or the clothing, ointments containing the red oxide, or the ammonio-chloride (white precipitate), will often suffice to cure, and have the advantage of being free from unpleasant colour or odour: mercurial fumigations may sometimes be required for the body. For the pediculus pubis, blue ointment is commonly prescribed,

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but it is not a pleasant application, and I have seen it produce much irritation. As in all cases when the hair is affected, destruction of the eggs or "nits," which are closely attached to the hair, is important for cure, and for this purpose, weak lotions of sublimate are good (2 to 3 gr. to 1 pint water), or strong lotions of vinegar, followed by the use of a dusting powder or ointment containing calomel or white precipitate.

Tinea Tonsurans — Pityriasis—Favus. — The parasitic growths upon which these unsightly maladies depend are destroyed by lotions containing 1 or 2 gr. of corrosive sublimate in the ounce, which should be applied once or twice daily after cleansing: ointments containing the same, or the ammonio-chloride, are also useful. Their curative effect, like that of all similar remedies, is dependent somewhat on the state of the general health in ringworm of the scalp, and in favus, but in ordinary ringworm of the body (tinea circinata), and in pityriasis versicolor, a few applications will suffice for cure.

Dr. Alder Smith has recommended the oleates of mercury as having more penetrating power, and records their proving curative in chronic and obstinate cases not amenable to lotions, blisters, etc.: for children under eight he uses a strength of 5 per cent., and for others who can bear it, 10 per cent., mixed with acetic ether, 1 part to 7; after cutting the hair close, thorough washing, and drying, this is rubbed into the whole scalp regularly night and morning, a cap or turban being worn to keep any of the preparation off the face: it is important that the head should not be washed more than once a fortnight. Mercurial remedies should not be used too concentrated, or over too large a surface, for fear of producing severe constitutional effects; and it is well to remember that blistering increases the absorptive power of the skin (New York Med. Journ., July, 1858). Under the heading of "absorption" we have mentioned cases in which death followed inunction of the scalp for ringworm, and would refer again to one in which a single painting with a vesicating solution of sublimate (gr. x. ad ʒi.), caused salivation and death from mercurial poisoning (B. M. J., 1871). I have myself seen a case in which death resulted from the local use of a strong sublimate ointment, and more than one case in which serious symptoms resulted.

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Other Skin-Diseases. — In many non-parasitic forms of skin-disease, mercurials are useful locally; sometimes by a "resolvent" action or quickening of the functions of the absorbents; sometimes by stimulating the epithelial and other tissues also; sometimes by exciting irritation of "substitutive character;" and in some cases by a powerful caustic effect. In syphilitic affections they exert a "specific" power, and in many cases their local action is supplemented by a varying amount of general action consequent on absorption. The late Mr. Startin, perhaps an empirical but certainly a successful practitioner in his specialty, and Mr. Naylor, who followed him, were accustomed to introduce mercury in some form into the treatment of almost all their cases; and if we do not use it so much, it is only that we have become more cautious than our predecessors as to doing harm by remedies.

M. Gubler has specially drawn attention to the cure sometimes obtained by mercurial treatment in very chronic skin-inflammation, such as psoriasis and eczema, and observes that it is a last resource not to be neglected, even if it be not easy to explain its action.

Eczema—Herpes.—In the acute inflammatory stages of eczema mercurials are usually unsuitable as being irritant, but Dr. Spender speaks highly of the use of lotio hydrarg. nigra in eczema rubrum: he adds glycerine, and applies it fresh three times in twenty-four hours, without oiled silk (B. M. J., i., 1878, p. 286). In subacute and chronic stages, with thickening from infiltration of the cellular tissue, moderate crusting, scaling, and dryness of skin, mercurial ointments are very serviceable; that of the red oxide often irritates, even at this stage, and that of the ammonio-chloride, diluted 1 in 4 or 8, is more generally suitable: Niemeyer specially commends it for chronic eczematous patches on the face. When there is more than average secretion or irritation, better results are obtained by a combination with equal parts of lead, or of zinc ointment, and a formula much used for eczema capitis at the Skin Hospital, is the following: ℞. Plumbi acet. gr. x.; zinci oxidi, hydrarg. subchlor., ung. hydrarg. nitrat., āā gr. xx.; olei palmæ purif. fl. ʒss.; adipis recentis ʒss., misce: such ointments are useful in the chronic general eczema of childhood especially.

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For eczema mammæ, which is often very obstinate, Hebra uses sublimate-lotions (1 in 120), but they require great care if any lactation is continued. For eczema of the genitals, Devergie recommended a very much weaker solution of the same; Guéneau de Mussy prefers calomel (15 gr. to ½ oz. of lard). For eczema about the hands, and especially for "cracks" about the fingers and nails, an oleate of 5 per cent. strength is said to be very efficacious (Practitioner, vol. x.). I have found an ointment of hydrarg. am. chlor. gr. v. to ʒj. very useful for eczema capitis et aurium after thorough removal of the crusts, also for all cases of chronic eczema. In (non-parasitic) sycosis, mercurial ointments combined with sulphur give the best results. In herpes preputialis, calomel is a useful dusting powder.

Erythema—Ephelides (Freckles).—Many cosmetic waters owe their efficacy to a minute proportion of sublimate, or to an albuminate of mercury. M. Hardy's formula for the treatment of freckles contains lead acetate and zinc sulphate of each 40 gr., sublimate 8 gr., with alcohol 2 oz., and distilled water 4 oz.; it acts by slightly irritating the epidermis, so that this exfoliates quickly. For a more decided effect Hebra uses a stronger solution (about 4 gr. to 1 oz.), applying it for four hours till the skin grows red, or even is blistered, and then under soothing applications it peels off, leaving a new surface. For ordinary erythema of the face, a lotion containing 1 to 2 gr. in 4 oz. of almond mixture, with or without bismuth or zinc oxide, and spirits of wine, is very useful.

Acne.—The last formula is suitable for many cases of acne when sulphur would not be well borne; but the pustules of this disorder may often be aborted with still more satisfactory results by means of the acid nitrate of mercury. The apex of the pustules should be lightly touched with this, on a glass brush, or a match point, and the drop of liquid should be soon removed by blotting paper or sponge: some temporary irritation may be expected.

Psoriasis.—The application just described (of acid nitrate) has been recommended also for chronic patches of psoriasis, and especially for such as occur along the forehead at the roots of the hair, but it should be used with great caution. The ointments of white and of red precipitate have a certain value

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for psoriasis of the face, or scalp, or hands, because they have no unpleasant colour or smell, but they are seldom so efficacious as tarry preparations. The iodides, with iodide of potassium, are also recommended (Rochard, Lailler).

Prurigo—Chronic Lichen—Pruritus.—In all itching papular eruptions, hot dilute solutions of the perchloride are likely to give relief. Trousseau recommends a strength of 12 gr. to the pint, and justly lays stress upon the importance of its being used hot.

In *prurigo* the ointment of ammoniated mercury either alone, or combined with hydrocyanic acid, or with lead compounds, often gives relief, and *calomel ointment* is a good remedy for pruritus ani, and for pruritus of the scalp connected with chronic eczema or pityriasis.

Erysipelas—Eruption of Small-pox.—Evidence may be found both for and against the use of mercurial ointment (ung. hydrarg.) in these conditions (Stillé). The application cannot be depended on for the arrest of erysipelas, but it has some power to relieve the burning pain, and to lessen the chances of pitting in small-pox: it certainly can prevent the maturation of a vaccine vesicle. The late Dr. Hughes Bennett thought highly of this treatment, and Mr. J. F. Marson says that a mercurial plaster in use at the Children's Hospital, in Paris, answers well: it is a modification of the emplastrum Vigo c. mercurio, and contains 25 parts mercurial ointment with 10 of yellow wax and 6 of black pitch; it is most suitable for semi-confluent cases, where the patient can use a little care, for in severely confluent attacks the application would soon be rubbed off by the restless movements (Reynolds' System, vol. i.). There is also some risk of salivation, and other forms of ointment answer equally well, so that although I have tried mercurial preparations in such cases, I have latterly abandoned their use.

Inflamed Lymphatics—Adenitis, etc.—When the parotid, the testis, or the mammary gland is inflamed, gentle frictions with mercurial ointment, or applications of it on lint, are suitable: in chronic superficial glandular swellings resulting from inflammation, or especially from syphilis, and also to procure absorption of inflammatory products in an early stage before

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suppuration has occurred, the same treatment is useful. The 5 to 10 per cent. solution of the oleate painted on night and morning is excellent, and I have known it succeed quickly in some cases where ordinary blue ointment had failed. For inflammatory and congestive conditions of the *uterus*, but more particularly of the *ovaries*, a combination of mercurial and belladonna ointments in equal parts applied externally is sometimes useful. It has been recommended even in fibroid growths.

Serous Effusions—Pleurisy—Hydrocele.—I have not been able to satisfy myself of distinct benefit from mercurial frictions in pleuritic or pericardial effusions, though they have been considered useful by others: in *hydrocele* in children Kock uses an ointment of the cyanide (1 part in 4), rubbing a very small quantity into the scrotum daily for three to six weeks unless erythema supervene: in such cases I have sometimes successfully employed, as a paint, a 2 to 10 per cent. solution of the oleate.

Goître (Cysto-Adenoma of the Thyroid Gland).—In true goître, as distinguished from fibroid or purely cystic enlargements, an ointment of the red iodide of mercury succeeds, according to the large Indian experience of my colleague, Mr. Macnamara, better than any other remedy.[1] The strength he recommends is of 15 gr. to the ounce of cerate, more than this causing unnecessary pain and soreness. A thin coating of such an ointment should be smeared over the goître, which should then be exposed to the full rays of the sun, or at least to bright light: artificial heat is not so effective (Frodsham, Lancet, i., 1860). Within half an hour, smarting and burning are felt, and in another hour a blister forms, which needs to be treated only in the usual way. The good effects of the red iodide continue long after this blister has healed, the tumour decreasing day by day for several weeks. One application of the ointment every two months is sufficient for the most extreme cases. Mr. Macnamara has often seen tumours which extended from the chin to the breasts disappear after two or three ap-

[1] The credit of this application has been variously ascribed to Major Holmes, Captain Cunningham, or Grant. Mr. Macnamara's experience is based on 23,000 cases.

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plications; from ordinary blisters he has never seen benefit in such cases, and the expensive iodine ointment was found to act very slowly, compared to the mercurial preparation: he has never seen salivation produced by the red iodide, though it is said to have occurred in some exceptional cases.

Splenic and Glandular Enlargements.—Mr. Macnamara has also found the ointment of red iodide of mercury useful in the treatment of "spleen," meaning the chronic enlargement resulting from ague or malaria (ague cake): he gives at the same time "ague powders" (quinine). At Netley this ointment forms part of the accepted treatment for such cases, phosphates of iron, quinine, and strychnia being given internally (Murchison, B. M. J., i., 1867). Dr. Andrew reports advantage from the same ointment at St. Bartholomew's Hospital (Lancet, i., 1869). Of course, in the enlarged spleen, consequent on mechanical impediments to circulation, heart-disease, etc., or on blood-poisoning, as in typhoid, or on amyloid, or other structural degenerations, mercurial ointments are useless, and even in malarial enlargements harm may be done by them, because splenic disease seems to render the system peculiarly liable to salivation and other ill-effects of mercury. Sir Joseph Fayrer has observed serious results from its use in splenic cachexia, with tenderness of the organ and much debility (Med. Times, i., 1874). Mr. Macnamara, however, as above remarked, has never seen salivation from a judicious use of the iodide ointment, and in all chronic cases it ought to receive a fair trial.

The ointment is equally applicable in cases of strumous enlargement of lymphatic glands.

Inflamed Joints.—In any persistent articular inflammations, whether traumatic, gouty, or rheumatic, mercurial ointments or oleates are useful applied with friction two or three times daily. Mr. Scott (Bromley) earned a high reputation by his successful treatment of "white swelling," chronic synovitis, etc., with a mixture of mercurial ointment, camphor, soap, and cerate, applied on strips of lint firmly covered with plaster strapping. Although this method is useful I commonly prefer gentle friction with an ointment of the ammonio-chloride, beginning with a strength of 1 part of the officinal ointment to 4 of simple cerate,

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and using afterwards 1 part in 8 two or three times daily. Under this simple treatment, with rest, I have known good results, which other remedies had failed to procure: thus, in one case of chronic inflammation of the wrist-joint, where able surgical and hydropathic treatment had been fairly tried, this ointment relieved more than any other means, and in several cases of chronic disease of knee-joint already condemned to amputation, the limb has been saved (though with stiffened joint) by this application.[1]

Ulcerations—Whitlow.—In chronic indolent or suppurating sores, even when non-specific, the "black or yellow" lotions containing the respective oxides are very good applications—the ointment of the red oxide is a valuable stimulant. Martin has strongly recommended blue ointment in *whitlow*, rubbing it in every hour, in intervals of poulticing. I have also used this treatment with some advantage, but the frictions need not be so frequent. Chronic indolent ulcers of the leg, whether syphilitic or not, often heal quickly with small doses of mercury, and lotions or ointment of the same, when applied to a similar condition, produce cicatrization.

Syphilitic Ulcerations and Eruptions.—It is in these forms of disease that the efficacy of mercurial lotions and ointments is the most marked. For *condylomata*, calomel with astringents is a good dusting powder, but the acid nitrate, lightly applied, is still more effective: one application will sometimes destroy the growths when nitric acid alone, and other caustics have failed (Practitioner, Aug., 1874). The acid nitrate is also the best agent to employ in the rare cases when it is desired to destroy a chancre by caustic in its early stages. As a dressing for hard chancre and for squamous and ulcerative

[1] Mr. Marshall introduced, for these and other cases, the use of direct compounds of mercurial salts with oleic acid, as being "more elegant, economical, and efficacious." He recommends the yellow oxide to be precipitated by caustic potash from a solution in nitric acid, and then dissolved in oleic acid according to definite proportions—5 or 10 per cent. or stronger; the weaker solutions are clear, pale, yellow liquids, the stronger are opaque and unctuous, and being rather irritant, may cause pain. Mr. Marshall recommends 1 gr. of morphia to the drachm of ointment when much pain is present, as in pleuritis, and paints 10 to 30 drops over the affected part (Lancet, i., 1872). Morphia dissolves readily in oleic acid, and may thus be combined with the mercury.

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forms of cutaneous syphilide, the "emplastrum mercuriale" (Prussian form) is much commended by Dr. Liveing. It contains metallic mercury (3 oz.), turpentine (1½ oz.), and lead plaster (12 oz.).

For generalized syphilitic eruptions, especially those of papular or scaly character, baths of corrosive sublimate have been recommended by Baumé, Trousseau, and others; but their proportion of ½ oz. to each bath I think too large: headache, drowsiness, and sometimes colic and diarrhœa, were produced, and the skin irritated by them. Baths containing only 10 to 15 gr. have been found very useful for syphilitic infants.

Epithelioma—Lupus.—Cases of epithelioma have been cured by repeated painting with the acid nitrate of mercury, the morbid growth being destroyed in layers (Gay, B. M. J., i., 1862); and this mode of treatment is applicable with due care in instances where operation is not desirable. It has been used to the *cervix uteri*, but has sometimes caused severe salivation, so that it has not been generally adopted: bromine is more suitable.

Extending patches of lupus are often controlled by the nitrate, but it is not so useful in the *erythematous*, as in the *ulcerative* and *discharging* forms: its application is very painful, and should not be repeated more than once or twice weekly, and should be followed by soothing remedies. In chronic torpid ulcerative conditions, M. Lailler recommends an ointment containing the red iodide with iodide of potassium (about 7 gr. of each in 3 oz.), it is useful but irritant: it may be applied stronger to non-ulcerative forms. Cinnabar is combined with arsenic in "Cosme's paste," which is very useful for superficial lupus patches about the face: three applications are usually made, for twenty-four hours each time (*v.* p. 442).

Diseases of Mucous Membrane—Syphilitic Throat, Tongue, etc.—In ulcerative conditions due to syphilis, gargles of "black-wash" or applications of calomel in substance are most useful: more active effects are, however, to be obtained from painting with dilute acid nitrate—1 part in 8 or in 16: 1 min. to 1 oz. of water is sufficient for a spray (Lyster, Liverpool Hosp. Rep., 1870). Trousseau used cigarettes for these and for laryngeal affections. A gargle of bicyanide of

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mercury (½ gr. to 1 oz.) is most useful when black-wash and other preparations fail.

For syphilitic and other ulcerations of the *Schneiderian membrane*, an ointment of the grey oxide is preferred (℥ss. ad ℥ss.): a powder containing cyanide of mercury and camphor may be cautiously used.

In *Ozæna*, injections of black or yellow mercurial lotion are of some service, with powders for insufflation, containing calomel, bismuth, and white sugar.

In *Chronic Angina*, good results have been obtained from the local use of the diluted acid nitrate of mercury (1 part to 6). It has relieved "nervous cough," and also, it is said, spasmodic asthma (Bull. de Thérap., xxiii., 1842)—this would be of reflex character.

For *Chronic Laryngitis and Eustachian Catarrh*, Dr. Nevins has written in favour of mercurial vapour: it may be obtained from cigarettes made with blotting-paper soaked in a solution of nitrate (Trousseau).

In **Strumous and Catarrhal Ophthalmia** a lotion of corrosive sublimate is one of the best remedies, especially in conjunction with the internal use of the same preparation, or of calomel: 1 or 2 gr. of the sublimate are to be dissolved in 6 oz. of water, and of this, 2 dr. with an equal part of hot water applied three times daily. Under this lotion the conjunctival redness is lessened, the corneal pustules and ulcerations of the lids heal, whilst the discharge, the lachrymation, photophobia, and irritability of the adjacent mucous membrane all diminish. In this affection is well seen the special power of mercury to check threatening suppuration and to heal ulceration.

In **Blepharitis**, when the sebaceous glands near the ciliæ become inflamed or obstructed, causing redness, crusting, and irritation, mercurial lotions, or ointments, applied at bedtime after due cleansing, are very serviceable. Calomel ointment is the mildest, that of the red oxide the most energetic (B. Carter), but that of the freshly-precipitated yellow oxide, introduced by Pagenstecher, is now the most generally used (Ophthalm. Rev., v. ii., 115). I have been well satisfied with the effect of white precipitate ointment diluted with three or four parts of lard, and Haltenhoff (Geneva) prefers this.

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Hordeolum (or "stye") is often best treated by applications of the same three or four times daily.

Phlyctenular Ophthalmia and **Keratitis** of scrofulous character have been cured by insufflations of calomel.

THERAPEUTICAL ACTION.—*Internal.*—A general effect may be obtained, as we have already seen, from local applications made in several ways—by inunction, by endermic painting, or hypodermic injection, as well as by suppository or fumigation. These methods, which will be more fully described afterwards, are utilized for mercury more than for other drugs, yet the ordinary mode of administration is simpler, and with due attention to the mouth and the digestion, is more satisfactory when the conditions of the illness admit of it.

Inflammatory Diseases.—From the time that Robert Hamilton described his successful treatment of inflammation by calomel and opium (Duncan's Commentaries, 1764) down to perhaps twenty or thirty years ago, mercury in some form was, in English practice at least, the almost universal remedy both for acute inflammations, and for their results, such as effusions, adhesions, and indurations. Trousseau described mercurials as "les antiphlogistiques les plus puissants"—more active, perhaps, than blood-letting,—and Nothnagel remarks that at one time the name of any malady ending in "itis" seemed sufficient to indicate their use. Sir Thomas Watson, in the later editions of his classic Lectures, quotes his own earlier opinion that "mercury is a very powerful agent in controlling inflammation, especially when acute and 'adhesive' in character, also in preventing exudation," but owns that this can be said no longer—"it requires much qualification" (5th Ed., 1871). This is perhaps the most important point in which modern experience and opinion would discredit the therapeutical power of mercury. It is not denied that full doses can act destructively on the blood and the tissues, though we have given some evidence against its aplastic energy (*v.* p. 634), but modern clinical experience affirms that it has not *great*, but comparatively *little* power over *acute* inflammatory disorders, that these often run a natural course towards recovery independent of mercurial, or other medicinal treatment, and that when it is pressed to a full effect con-

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valescence is protracted by greater anæmia and debility. (The unquestioned good results recorded from the treatment of Hamilton, which led to its general adoption, have been plausibly attributed to the *opium* rather than to the *mercury*.) Sufficient account of the evils that followed was not made by our predecessors, who, knowing too little of the natural history of disease, attributed all bad sequelæ to *it* rather than to the medicines, and considered themselves successful if, when "the disease was subdued," life at least was saved.

We cannot, on the other hand, agree with the assertion that mercury is never useful but always injurious in inflammation. There is evidence of its advantage in certain conditions, though this evidence is not so consistent nor so general as of its value in syphilis. It will certainly remedy some of the *results* of inflammation, as chronic effusions in joints or lungs, and, as Dr. Stephenson remarks when narrating such cases, no number of instances in which the medicine has been abused, or even has failed, can contradict the cases in which it has conferred evident benefit (Edin. Med. Journ., 1871). Dr. Habershon allows its value in cases of retained secretion, dropsy, gastric disorder, as a purgative, and as anti-syphilitic, but objects to its use in all degenerations and passive congestions, in fevers and exhausted conditions, in diseases of mucous membrane, in rheumatism, and *all inflammations* of lung, brain, etc. (Pamphlet on Mercury, Brit. and For. Rev., ii., 1860). For my own part, I still hold it useful in many chronic inflammations, whether syphilitic or not, affecting mucous and parenchymatous tissues, and having a general tendency to suppuration and ulceration, but I am satisfied that it should never be pushed to salivation.

Meningitis, and Cerebral Disorders.—The principal difficulty in judging of the effects of mercury in meningitis, and of the relative value of recorded cases, lies in the uncertainty of diagnosis. Cases of cerebral congestion, in children especially, present at first symptoms very similar to those of simple meningitis, such as pain in the head, vomiting, injection of the eyes, excitement followed by semi-coma, pyrexia, and even convulsion. Many years ago I usually treated such cases with minute doses of perchloride or iodide of mercury, and, as I thought, with moderately good results, but further experience has not satisfied me

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on this point. Many surgeons prescribe it in traumatic cases, and believe it relieves the fulness of the cerebral vessels, and although Dr. Ramskill (Reynolds' System), Stromeyer, and some other authorities might be quoted as still commending mercurial influence in meningitis, the general tendency of modern opinion is decidedly against its value. In many recent text-books, in Dr. Bristowe's for instance, it is not even mentioned. When the malady follows on febrile or eruptive diseases, or spreads from caries—*e.g.*, in the ear-bones—mercury is not likely to relieve it, and in other idiopathic or at least non-tubercular cases, I think aconite, belladonna, and bromides are of more importance in the early stages, and nourishment and perhaps iodides in the later ones. In cases presumed tuberculous I use iodide of potassium, generally with cinchona. Dr. Copeman, when narrating several cases of apoplexy and cerebral disorder in illustration of the beneficial action of mercury, fully adopts the proposition that it cannot prevent inflammation, but may cause absorption of its results—effusions, adhesions, etc.: he strongly advises its use, therefore, in all inflammations of *vital* organs, after the acute stage is passed (Med.-Chir. Rev., i., 1872). I have seen it of some service in such cases, but many remain quite unaffected by it.

Chronic Hydrocephalus.—Of this disease, Gölis recorded a large number of cures under ¼ to ½-gr. doses of calomel twice daily, and mercurial inunctions of the scalp, but his results were not confirmed by other observers. Sir T. Watson refers to two remarkable cases cured by a mixture of metallic mercury 10 gr., fresh squill 5 gr., and manna, taken three times daily for three weeks: it caused weakness, emaciation and diuresis, but not ptyalism. I have not myself seen any good result in this condition from mercury.

Pericarditis.—To treat this inflammation without mercury would, a generation ago, have been reckoned almost criminal, and men no less eminent than Graves and Stokes have left their emphatic testimony in its favour—the latter gave 20 gr. of calomel once or twice daily. Yet soon afterwards, Markham and Walshe began to doubt its value, and Todd denied it wholly. Watson says, "I am obliged to recant my advice as to giving mercury in acute pericarditis" (Lectures, 1871), and Hayden

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is almost alone amongst modern writers in still recommending calomel and antimony (Diseases of Heart, 1876). Waters, Austin Flint, and Loomis have discarded mercurials, and Sibson, in his able monograph, does not even mention them (Reynolds' System, vol. iv.). Dr. Garrod states that full mercurial treatment of the joint-affection in rheumatism will not prevent pericarditis, and it would seem, therefore, scarcely likely to arrest it after its commencement: further, as it is almost always connected with, or dependent upon, rheumatism, its treatment should naturally be conducted on the same principles, and as we do not now give mercury for the main disease, why should we do so for one of its local manifestations? I have myself carefully watched its effects several times, and although the bruit and other physical signs have varied during the attack, I have never been able to satisfy myself of a definite influence of the drug upon the malady: on the contrary, I have seen this prolonged to more than an ordinary duration, whilst the gums have been sore. In subacute or chronic cases, where effusion has occurred and is persistent, I have seen benefit from small doses of sublimate or grey powder and mercurial applications locally, but when the effusion is very large, the pulse feeble, and cardiac paralysis threatening, any excess of mercury must be carefully avoided (Nothnagel).

Endocarditis.—In rheumatic endocarditis, on account of the still more serious issues involved in exudation and adhesion, more advocates are to be found for the use of mercury in the hope, at least, of controlling such results. I cannot dogmatize on this question, but I place more confidence in opium and rest.

Pleuritis.—Fuller and Walshe may be named amongst modern advocates of mercurial treatment in pleurisy, but for the acute stage I cannot see its advantage, since aconite, salines, belladonna, or morphia, with suitable local applications, give usually all the good results that can be expected from medicines. When effusion has occurred, however, I believe that mercury may be of considerable service in stimulating the absorbents; and in some cases, when hectic has set in and there have been signs of commencing pus-formation, small doses of corrosive sublimate have seemed to me advantageous. I have also noted benefit from this medicine in pleuritis occurring in puerperal women, and a similar observation is recorded by Nothnagel.

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In no case should it be pushed to the production of salivation or anæmia.

Peritonitis.—Velpeau was the great advocate for a thorough mercurial treatment of this inflammation, and by enormous doses of calomel used concurrently with inunctions, he expected so to alter the blood in a few hours as "to prevent its furnishing the elements of a severe inflammation." Trousseau adopted for some time a similar method, for which he substituted later that of Dr. Law, giving minute doses frequently. Without accepting Velpeau's theory, it may be said that mercurial treatment—or rather calomel with opium—has been less completely abandoned in this inflammation than in many others. Watson certainly says "he is doubtful if it has ever done good, whilst if it purge it must do harm," but I believe that small doses of calomel or of sublimate ($\frac{1}{100}$ to $\frac{1}{30}$ gr.) have conduced to the recovery of some of my cases of acute and "idiopathic" peritonitis. I have generally given them every one to three hours alternately with aconite, and used opium as required for relief of pain. In localized forms of peritonitis, occurring, for instance, after perforation, or from peri-typhlitis, opium is the most important remedy.

Pneumonia.—In the early stages of acute pneumonia, formerly treated by calomel and antimony, I cannot recommend mercurials, but the time for using them with advantage is when secondary fever arises, and there is reason to fear purulent degeneration. So far as I can judge, they have seemed to exert some power in preventing this, for certain cases of the kind have improved on commencing the use of sublimate, and others have relapsed on its omission. In pleuro-pneumonia, with copious effusion, the same remedy is still more clearly indicated, and in chronic interstitial pneumonia it sometimes has excellent effect. Sometimes a syphilitic or strumous deposit occurs in the lung, rendering it partially solid, and giving the physical signs of a pneumonia, and these deposits, especially when of the former nature, seem to "melt away" under the moderate action of mercury: but careful diagnosis of such cases is required, for in true tubercular deposit the drug is injurious. Graves speaks highly of mercury "in scrofulous inflammation of the lung."

Bronchitis.—In acute cases, with much congestion of mucous

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membrane and scanty expectoration, small doses of perchloride are often useful. In certain cases narrated by Thorowgood, blue pill with squill was given with apparent advantage, when there was "severe cough at night, pyrexia with loaded urine, dyspnœa, some lividity of lips, difficult scanty expectoration, with râles, and perhaps impaired resonance" (Practitioner, i., 1878): this treatment is more suitable for robust adults than for the aged. In catarrhal bronchitis passing into pneumonia, frictions of the chest with oleate of mercury are said to be useful.

Coryza.—In ordinary coryza, especially when there is much sneezing, I have often found small doses of grey powder cure more quickly than any other remedy. Catarrh affecting the Eustachian tube is also well treated in the same manner.

Diphtheria—Croup (Laryngeal Diphtheria).—Stillé, after giving many authorities in favour of the mercurial treatment of diphtheritic disease, says himself "that it appears urgent that the system should be brought under mercurial influence as speedily as possible," and following Albers, he recommends ¼ gr. of calomel every hour, and a scruple of mercurial ointment to be rubbed at intervals into the thighs. Trousseau, finding that the direct application of calomel to external diphtheritic surfaces modified favourably their condition, recommended its use by insufflation, or by allowing it to mingle slowly with the saliva; this has not, however, given much result. Bretonneau used mercurials freely, but his mortality was great, and contributed to induce a general distrust of the treatment. West, however (Ed. 1859), still considered calomel useful for "counteracting the tendency to formation of false membrane and preventing lung-inflammation." I have been myself much disappointed with the action of calomel in these respects, but the red iodide and the cyanide of mercury, in doses of $\frac{1}{50}$ to $\frac{1}{30}$ gr. every two to four hours, have exerted a more favourable influence in some severe cases. It is very important to watch their action carefully, and not to induce salivation, for according to general experience "this promotes rather than checks the spread of exudation" (Mackenzie), and certainly, as a general rule, other remedies of a tonic or antiseptic character are often to be preferred to mercurials.

Tonsillitis, etc.—In ordinary tonsillitis, and even in sup-

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puration about the fauces, I have seen much advantage from small doses of hydrarg. c. cretâ. In early stages of quinsy, in ulcerated sore throat, and even in the "putrid" form (cynanche maligna), ½ gr. given every two to four hours has induced rapid improvement. It does not exclude the use of aconite or belladonna if indicated by high temperature or much pain. In parotitis ("mumps"), also in glossitis, "cancrum oris," and cracks and ulcerations about the mouth and lips, the same treatment is very effective. For relaxed congested conditions of the faucial membrane the value of dilute solution of mercurial nitrate has been already indicated.

Scarlatina.—The small doses of hydrarg. c. cretâ just mentioned I have found equally useful in the severe specific sore throat of scarlatina, especially when the cervical glands and adjacent cellular tissue are inflamed and swollen, and when there is ulceration or even a tendency to gangrene.

Morbilli.—Half-grain or quarter-grain doses of grey powder given every four hours will also control the catarrhal symptoms of measles: when the conjunctivæ and mucous lining of the nose, mouth, and throat are inflamed, and even when ulceration is present, they render excellent service.

Variola.—When the eruption is passing into the pustular stage, and when secondary fever is setting in, I can recommend ½-gr. doses of hydrarg. c. cretâ every three to four hours, for a few days. Unless the gums show signs of tenderness, this treatment tends to check and limit suppuration, and consequently to lessen in some degree the chances of pitting. The local use of mercurial ointment has been already mentioned (*v.* p. 651).

Enteric Fever.—We need not here refer to the older method of treating this fever by repeated purgative doses of calomel (*v.* Stillé), a method not now advocated,—but several eminent physicians abroad—Traube, Wunderlich, Liebermeister, and others, have recently recommended a "specific" treatment for the first nine days of this fever by calomel, giving 10 gr. in a single dose the first day, and 8 gr. (in divided doses) daily for three or four days afterwards. They claim for these doses an antipyretic effect, and a power of lessening both the duration and the mortality of the disease (Med. Times, ii., 1876). I have not had experience of this treatment, nor, although foreign

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statistics show good results, has it made way in this country. An early moderate purgative dose is, however, often advisable, and Black has written to recommend one or two 5-gr. doses of calomel during the first week, as "antiseptic" (Lancet, i., 1875). Corrosive sublimate in minute quantities has also proved valuable in typhoid diarrhœa (B. M. J., i., 1874), and this is in accord with my experience, but with these exceptions mercury is not indicated in the treatment of this fever.

Puerperal Fever.—Traube has also revived mercurial treatment in some cases of this disease—not for the general blood-poisoning—but at the commencement, when phlegmonous inflammation is spreading from the uterus, and involving other parts, *e.g.*, the peritoneum or pleura. He considers that a rapid and energetic mercurializing by calomel and inunction gives the best results, and states that such cases bear large doses, and that improvement generally coincides with the first signs of salivation. Spiegelberg especially observed the good influence of corrosive sublimate in similar conditions—he gave $\frac{1}{8}$ gr. at a time (Nothnagel). Concerning this treatment, I can only say that I have not had occasion to adopt it, aconite, opium, quinine, etc., seeming to be much more desirable remedies.

Erysipelas.—In many cases of phlegmonous erysipelas, especially when occurring in strumous subjects, I have found the internal administration of corrosive sublimate distinctly useful.

Syphilis.—In 1497 Gilinus first employed mercury in the treatment of the then epidemic of syphilis, borrowing his practice from that of the Arabians in skin-diseases, and using only external applications, by friction, bath, or fumigation. Several serious accidents that occurred from the remedy as used by empirics contributed to discredit it, and in 1517 it was almost entirely superseded by guaiacum. Not long afterwards, however, the internal administration of corrosive sublimate, red precipitate, and calomel became general, and by the time of Boerhaave was carried to such excess that mercurial treatment was not considered thorough and satisfactory till it secured the ejection of three or four pounds of saliva in twenty-four hours. But some protest against such abuse was not wanting, and between mercurialists and anti-mercurialists sprung up a con-

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troversy which has lasted to our own time. In the early part of this century a reaction of opinion against the extravagant use of the drug in syphilis became general—thanks mainly to Rose and Guthrie, Thomson and Abernethy—and it was proved that syphilis sometimes tended to spontaneous cure, and yielded to non-mercurial treatment. Later on, an important distinction was made out between the soft or non-infective, and the hard infective sore, and professional opinion pronounced strongly in favour of mercury for the latter, whilst allowing it unnecessary in the former, and in gonorrhœa. This was clearly evidenced in the report of the Admiralty Commissioners on the subject, which records the opinions of forty eminent practitioners (1864). Amongst others, Sir James Paget called mercury "a specific—if the patient could take it well; in favourable cases it would prevent secondary symptoms, and at least it would shorten their duration." Mr. Hutchinson speaks of it as a "true vital antidote, and if given early, as really stopping the development of symptoms, and absolutely curing the disease." Whilst agreeing in the main with this conclusion, I do not discard wholly the use of mercury in soft chancre, for I find that small doses cause the sore to heal more quickly than any other medicine.

Constitutional syphilis is commonly divided into three stages, fairly well distinguished as primary, secondary, and tertiary, and the best period for giving the remedy has been much discussed. Some have maintained that its early exhibition only *defers* the appearance of secondaries, and it is better for these to appear and then to give mercury till they disappear; but the best authorities favour early commencement. Ricord gave mercury—generally the iodide—so soon as the hard chancre was distinctly diagnosed, and insisting on a year's continuance of treatment, was satisfied that he prevented secondary symptoms. Barallier supported the same conclusion after much experience amongst sailors. The majority of British surgeons follow this practice at present, and it seems to me the right one.

On the other hand, most are agreed that in tertiary stages of syphilis, mercury is not a desirable remedy, and Dr. Wilks finds a reason for this in the different processes which occur at different periods of the malady. In the primary and secondary periods, plastic lymph is being effused, but in later stages degeneration

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is going on; mercury causes absorption of the effused products, but its *further* action can only assist degeneration, induce cachexia, and be thus injurious (Guy's Rep., vol. ix.). As clinical evidence of this, if any were needed, reference might be made to the cases recorded by Mr. Hutchinson, where phagedænic ulceration in delicate subjects distinctly increased under the influence of mercury (Lond. Hosp. Rep., vol. ii.). Also, if any syphilitic sore be much inflamed, or if aggravated dyspepsia, anæmia, phthisis, or albuminuria is present, special treatment for these conditions must be instituted independently of mercury. Pregnancy has been, by some, considered a bar to due mercurial treatment, but, in my opinion, the danger of miscarriage in the mother, and of injury to the infant, are greater from syphilis than from mercury.

In any case, a moderate use of the drug must be the rule. It is true that Trousseau and Pidoux blame a relaxation of the old methods for what they consider the present gravity of the disorder; but the large majority of the best authorities, including Ricord, Sigmund, and Hutchinson, deprecate full mercurialization, and find the best effects from small doses continued for a long time. Sigmund states that of nearly 9,000 patients treated in the Vienna Hospital, 8,500 showed no sign of salivation, but were cured as permanently as those salivated (Med.-Chir. Rev., July, 1858). Slight tenderness of the gums may be safely and properly produced as evidence of systemic influence, and a method, sometimes successful, is to give fractional doses ($\frac{1}{12}$ gr.) of calomel every hour; given in this manner, 3 gr. may suffice for the purpose (Law, Dublin). In all forms of *tertiary* syphilis, rupia, and deep ulcerations, especially of mucous membranes, tongue, and fauces, gummata, visceral syphilis, and most syphilitic nerve-affections, the great remedy is not mercury, but iodide of potassium, though in hereditary syphilis mercury is still to be preferred.

In *syphilitic iritis* and *retinitis*, the early and sufficient use of mercury is perhaps more clearly indicated than in any other inflammation, and they are the only conditions in which Ricord held even salivation justified. Watson has graphically described how effused lymph in the anterior chamber may be seen to

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"melt away," under the influence of the drug; but unfortunately, this is evident only in syphilitic cases. I often combine with its internal use, collyria of corrosive sublimate, 1 to 2 gr. in 6 oz. of water with opium, or an ointment of ammonio-chloride with belladonna for frictions round the orbit, with good success; but the same treatment cannot be depended upon in rheumatic or traumatic cases.

In *syphilitic laryngitis* also, mercury must be promptly and freely used, for in acute cases life is rapidly endangered by the disease. Syphilitic infants, as a rule, develop only a subacute form of this disease, which may be treated less actively by moderate frictions with very satisfactory result. (For *catarrhal* laryngitis, mercury is not indicated).

Scrofula.—Not only in syphilitic, but also in scrofulous diseases, small doses of mercury are useful. I know that this is not so commonly recognized, but ½ or 1-gr. doses of hydrarg. c. creta twice daily will often be found of great advantage in purulent discharges from the eye, ear, etc., as also in chronic glandular swellings.

Hepatitis.—Annesley recommended in this inflammation, large doses of calomel to the production of salivation, which he looked upon as "derivative," and no doubt at one time, as Maclean observes, "faith in calomel may be said to have attained in India to the dignity of a dogma." He, himself, strongly objects to any systematic use of mercury, and suggests that if it has gained credit for preventing suppuration, this has been in cases which were really of "*peri-hepatitis*," and not likely to end in abscess; in a large experience he has never seen it arrest suppuration, and "disbelieves in any such power" (Reynolds' System, vol. iii.). Morehead and Waring agree in this opinion, and Massy reports serious impairment of health after its free exhibition. These authors may be taken as representing the present state of general opinion, but I think they have been too strongly prejudiced against the remedy by its excessive use, or abuse, and that small continued doses, stopping short of any full physiological effect, may still be found of advantage in commencing hepatitis; occasionally, larger (purgative) doses act well. In chronic forms of liver inflammation, when the viscus is large and tender, mercury is also suitable, though if

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marked cachexia be present, or suppuration be fully developed, the drug is better avoided.

Cirrhosis.—Monneret has strongly recommended moderate doses of blue pill in cirrhosis with dropsy (Archives Gén., Sept., 1851), stating that after the numerous stools and copious sweatings induced, effusions are often absorbed, without any ill-effects from salivation. Barallier corroborated this experience, and further reported a case, not far advanced, which was cured by this treatment (Dictionnaire). I have certainly had the best effects from mercury in cirrhotic dropsy, but have generally used purgative doses of blue pill, or calomel, followed by salines, and in the intervals of purgation have given nux vomica and other tonics. Under such treatment large abdominal effusions have passed away six times in one case, at different intervals, so that the patient was restored to comparative health for some time, and this without any mercurial ill-effects. The diagnosis was verified post-mortem, but I cannot say that I have seen the malady permanently cured by this or any other treatment.

Hepatic Congestion—Constipation.—In torpor, or subacute congestion of the liver, marked by coated tongue, yellowish countenance, headache, nausea, depression, light-coloured stools, etc., a moderate mercurial purge, especially with a saline, will commonly relieve more quickly than any other medication (unless it be sometimes podophyllin), and no amount of experiment on animals can alter this clinical fact. The great experience and authority of Murchison quite corroborate this (Lancet, 1874), and Dr. Duckworth has lately drawn renewed attention to the good results of calomel in acute gastric catarrh and "biliousness" (Practitioner, July, 1876). In chronic cases of this kind it is, however, advisable not to resort frequently to this remedy, but to depend rather upon diet, hygiene, and saline or vegetable aperients, though small doses—$\frac{1}{30}$ to $\frac{1}{20}$ gr. of corrosive sublimate at bedtime—have a good effect. The use of metallic mercury as a purgative might be thought obsolete, but an instance of it has been recently recorded, where obstinate obstruction and vomiting were present: 1 oz. of quicksilver was given in two doses at half an hour's interval; it soon acted, and recovery followed (Lancet, i., 1874, p. 54). I have myself used it in two cases lately: one was that of a boy, aged eight, who

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had had obstruction for five days, and although under active and competent treatment, continued to get worse, with vomiting, pain and accumulation over ilio-cæcal valve, distension, etc. Surgical interference was desired by the parents, but in consultation it was agreed to try mercury first, and 1 oz. was given in the manner just described. It was readily taken, and some of it soon passed, but without producing a motion; the symptoms improved, and on the following morning we gave castor oil which acted well, and the child soon recovered. The whole of the quicksilver passed was collected and weighed and found to amount exactly to the ounce taken. In a second case, a girl, aged between five and six, the obstruction had lasted several days, and the vomiting and other symptoms were persistent in spite of croton oil, etc. I recommended, at first, treatment by opium, which was steadily continued for three days, but without benefit; castor oil was then given but was rejected; we then gave 2 dr. of quicksilver, in five minutes afterwards another 2 dr., and in half a hour a third and similar dose. It made its appearance from the rectum in about two hours, bringing wind but not much fæcal matter; we followed up the mineral with castor oil, which was retained and acted, and the child gradually got well.

Vomiting.—In some forms of obstinate vomiting, dependent upon disordered stomach, with hepatic congestion, 3 to 5 gr. of calomel in pill or powder, have a most beneficial effect. The dose should be followed after a few hours by a saline purge.

Diarrhœa (Infantile).—When the motions are green, curdled, watery, and offensive, small doses (¼ gr.) of grey powder act very well, especially when combined with bismuth, and the same powders are useful when curdled milk is frequently rejected from the stomach. When there is a simple diarrhœa, with whitish stools, Dr. Stephenson thinks that rhubarb and soda should replace the mercurial, for fear the latter should depress the strength (Edin. Med. Journ., 1871), and certainly, if it be continued unwisely, it may do so by irritating the mucous membrane, etc., but I have never seen ill-effects from the minute doses above recommended. For infantile watery diarrhœa $\frac{1}{100}$ to $\frac{1}{50}$ gr. of corrosive sublimate after each motion acts well (with due care). I think this is now a common experience; I have

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acted upon it for twenty-five years. In the acute diarrhœa and colic of adults, one of the best methods of treatment is the use of a pill of calomel (3 gr.) with opium (1 gr. or ½ gr.), followed, after three or four hours, by castor oil or other laxatives.

Dysentery.—In acute dysentery, with violent pain, severe prostration and frequent muco-sanguineous stools, small doses of corrosive sublimate, given at short intervals, commonly relieve in a few hours, and almost in a "specific" manner—certainly better than any other remedy I have known. Sublimate is equally useful in the "white dysentery" of Ceylon and India. I have seen the best results from it when opium, lead, and other astringents had proved useless. I thus agree with Wood, who asserts that in this malady "no remedial influence is more effective than that of mercury," rather than with Maclean, who deprecates its use in all forms and stages. I can only suppose that the injurious effects traced by him and by others to calomel, etc., resulted from doses that were too large.

Cholera.—Dr. Maclean equally objects to any preparation of mercury in cholera, as "useless in collapse and dangerous when reviving" (Lancet, 1866), but although I am not myself an advocate for the calomel treatment, the results obtained by Dr. Ayre, of Hull, deserve attention. He gave ¼ to ½ gr. calomel every ten minutes or every four hours, according to circumstances; it rarely salivated, but produced apparently good results in a majority of cases. Bloxam and some other observers have followed the same plan with advantage, and Niemeyer speaks well of calomel treatment. What is desired is to stimulate by this means a secretion of bile and to promote elimination, for we know that the reappearance of bile in choleraic stools is a favourable sign; besides this, large doses of calomel (½ dr.) have been said "to restore warmth" (Brit. and For. Rev., i., 1870). Köhler thinks that its good effects are owing to the disinfecting property of the drug when brought into contact with the contents of the intestines. Of fifty-six cases, some of which received 200 gr. in two days, twenty-one died, but the reporter seems to think the results favourable to the treatment by calomel (Lancet, i., 1874). The general experience of the profession has not, however, adopted it, and it is clearly not free from danger, for under certain conditions a quantity of the

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medicine may remain for a time unabsorbed, and afterwards produce serious toxic effects.

Intestinal Worms.—Calomel is a very suitable vermifuge in cases of ascarides. Both the round and the thread worms are expelled under the influence of 2 to 5 gr., which may be given early in the morning and followed in a few hours by a purgative draught. It is usual to combine the dose with powdered jalap, but I have found the mercurial alone sufficient, and it is more readily taken. Dr. Stillé speaks well of the effect of a small portion of mercurial ointment placed in the rectum daily at bed-time, for destroying ascarides, also of the injection of ¼ to 1 gr. of corrosive sublimate dissolved in water, but I doubt the wisdom of this treatment.

PREPARATIONS AND DOSE.—*Hydrargyrum cum cretâ* (contains 1 part of the metal to 2 of prepared chalk, rubbed together until globules cease to be visible): dose, for children, ½ to 2 gr., less or more; for adults, 3 to 8 gr., or less. *Pilula hydrargyri* (contains 2 parts of the metal with 3 of confection of roses, and 1 of powdered liquorice root): dose, as a purgative, 3 to 10 gr.; for constitutional effects, 2 to 3 gr. three times daily—may be well combined with quinine. *Emplastrum hydrargyri* (made with mercury, olive oil, sulphur, and lead plaster). *Emplastrum ammoniaci cum hydrargyro* (contains gum ammoniac in place of lead plaster, or in other words, ammoniacum and mercury plaster). An emplastrum mercuriale of the Prussian pharmacy is much used by Hebra and others in the treatment of syphilides, acne, etc., and is made according to the following formula—℞. Mercury ʒiij., turpentine ʒiss., lead plaster ʒxij. *Unguentum hydrargyri* (contains 1 part of mercury, 1 of prepared lard, and a little suet): this preparation should be lead-coloured; from ½ to 2 dr. may be rubbed into the armpit or inner side of the thigh at one or several frictions in the course of the day, according to the rapidity of the effect desired. A pleasanter compound than the officinal ointment may be prepared from the following formula of Magne Lehrens, of Toulouse—Mercury 1,000 grammes, oil of sweet almonds 20 grammes, balsam of Peru 20 grammes, lard 960 grammes. The metal disappears rapidly in the oil and balsam, and the result is

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a smooth pomade, blue, agreeable in odour, and easily kept. Mr. Marshall's formula for oleates, already mentioned, is designed to prevent some of the unpleasantness of the ordinary blue ointment, and the following form, used in the marine hospital of Toulon, is calculated to produce constitutional effects without salivation :—℞. Slaked lime gr. xxx., chloride of ammonium gr. viij., sulphur gr. xxx., mercurial ointment gr. clxxx. This ointment dries very readily, and is prescribed in double the ordinary quantity. *Hydrargyri oleas:* made 5 to 10 per cent. and upwards (*v.* p. 654). *Unguentum hydrargyri compositum* (contains mercurial ointment, yellow wax, and olive oil and camphor) : this combines the medicinal properties of mercurial ointment and camphor, to which wax and oil are added to give a suitable consistence; it is used as a stimulant to swollen glands, and for chronic inflammation of joints, and represents "Scott's ointment." *Linimentum hydrargyri* (contains equal parts of blue ointment, solution of ammonia, and camphor liniment) : it should be a lead-coloured cream ; this readily produces salivation. *Suppositoria hydrargyri* (contain mercurial ointment, benzoated lard, white wax, and oil of theobroma) : there are 5 gr. of blue ointment in each suppository.

Hydrargyri subchloridum: dose, as a purgative, for children, 2 to 3 gr.; for adults, 2 to 5 gr. ; for constitutional effects ½ to 1 gr. or more, frequently repeated, or $\frac{1}{10}$ gr. may be given every hour (3 to 4 gr. in this manner sometimes produce mercurial action), or ¼ to ½ gr. or more may be given night and morning combined with a fractional quantity of opium. *Lotio hydrargyri nigra* (contains 3 gr. of calomel to the ounce of lime-water). *Pilula hydrargyri subchloridi composita — Plummer's pill* (contains calomel, sulphurated antimony, guaiac resin, and castor oil) : each 5 gr. of the pill mass contains 1 gr. of calomel and 1 gr. of sulphurated antimony; calomel should not be given with alkaline carbonates, as corrosive sublimate is liable to be formed. *Unguentum hydrargyri subchloridi* (6½ gr. of this ointment contain 1 gr. of calomel). *Hydrargyri perchloridum:* dose, $\frac{1}{60}$ to ¼ gr. in solution or in pill : but very much smaller doses are used. *Liquor hydrargyri perchloridi* (contains ½ gr. of perchloride and ½ gr. of ammonium chloride to each fluid ounce, or $\frac{1}{10}$ gr. of each to the drachm) : dose, ½ to 2 dr., *i.e.*, $\frac{1}{10}$ to ⅛ gr.,

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but I prefer smaller doses, as mentioned above. *Lotio hydrargyri flava* (contains 18 gr. of corrosive sublimate in 10 oz. of lime-water).

Hydrargyrum ammoniatum ("white precipitate"): not used internally. *Unguentum hydrargyri ammoniati:* 1 part of ammoniated mercury in 8 of ointment.

Hydrargyri iodidum viride: dose, ½ to 3 gr. *Hydrargyri iodidum rubrum:* dose, $\frac{1}{16}$ to ⅛ gr., or less or more. *Unguentum hydrargyri iodidi rubri:* 1 part in 28 of ointment.

Hydrargyri oxidum flavum: used in the preparation of the oleate of mercury. *Hydrargyri oxidum rubrum:* for external use. *Unguentum hydrargyri oxidi rubri* (contains red oxide of mercury, yellow wax, and oil of almonds): there is about 1 gr. of red oxide in 8 gr. of the ointment.

Hydrargyri nitratis liquor acidus: used externally. *Unguentum hydrargyri nitratis* (citrine ointment): 1 part in 15½.

Hydrargyri sulphuretum—"artificial cinnabar" (not officinal): not used internally. Its fumes are used in syphilitic skin diseases, as ecthyma; also in syphilitic sore throat by inhalation, 30 gr. being heated on an iron plate and placed under the patient, who should be wrapped in a blanket; or the vapour may be inhaled through a funnel. *Hydrargyri sulphas:* not given as a remedy, but used in the preparation of corrosive sublimate and calomel.

Inunction.—The patient should be prepared for a course of mercurial inunction by simple dieting and by warm baths: and during it should be clothed in flannel and avoid exposure. When making the frictions himself, he should rub thoroughly in his hand the prescribed quantity of ointment, and then slowly and forcibly anoint certain parts of the body in a definite order: it is usual to choose the axillæ and the groins, but practically it is better to avoid parts with abundant hair-follicles. According to the German method of Zeissl, the inner side of both upper arms is first treated, on the next night the inner side of the thighs, then of the forearms, then of the legs, afterwards of the groin and of the back, so that an interval of several days is allowed between the friction of any one part, in order to avoid local soreness. The evening is the best time for the application,

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and warmth promotes its effect: the part should be kept covered during the night, and be cleansed on the following morning. When the patient is too ill, or for any reason is unable to apply the ointment himself, the attendant who uses it should protect his own hand with a leather or caoutchouc glove. In young children frictions are often made on the inner side of the soles of the feet, or a piece of ointment is simply placed on the inner side of a thin flannel binder. For adults, ½ dr. up to 2 dr. represents an average amount of mercurial ointment for daily use, but sometimes, as in peritonitis, 1 dr. has been ordered every hour: it is important that no rancid ointment be used, or severe irritation may be induced by it. This method of treatment has the advantage of saving the digestive tract from any direct irritation from the drug, and, according to Sir B. Brodie, "it cures better and injures the constitution less." This, however, scarcely holds true in view of the modern cautious administration of mercury, and the method of inunction is less often adopted than formerly, since it is, at the best, troublesome and uncleanly.

The *endermic* application of mercury is effected by dressing a blistered surface with blue ointment or sometimes with calomel. From the latter, purging has resulted, but as a rule the endermic method is employed for a local stimulating action on the absorbents, as in pleuritic, pericardial, or joint effusion, rather than to affect the general system.

Hypodermic Injection.—The best form for this purpose has been much discussed; Lewin, one of the first to recommend it, used 5 milligrammes of corrosive sublimate, but this is too much. Dr. Walker gave $\frac{1}{30}$ gr. in 10 min. of water and glycerine, and obtained good results in secondary syphilis without serious drawback, but Stohr, Greenfield, and others have reported local irritation, abscess, and even gangrene without therapeutical advantage. Liégeois added a minute quantity of morphia, but Staub's solution of albuminate of mercury secured more general approval. It is prepared with two separate solutions, thus,—corrosive sublimate, 1·25 gr.; chloride of ammonium, 1·25 gr.; chloride of sodium, 4·15 gr.; distilled water, 60 gr.: dissolve and filter. The second solution is made with the white of an egg very thoroughly agitated with 60 grammes of distilled

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water and filtered; the two liquids are then intimately mixed, and directed to be kept from the air as much as possible. The solution should, in fact, be prepared fresh as required, for it will not keep. One gramme contains 1 milligramme of the salt, and the dose should be about 1 centigramme daily at two injections. M. Bouilhon has recommended a solution containing a double iodide of mercury and sodium (Practitioner, 1869), and Scarenzi and Recordi the injection of calomel suspended in gum (Practitioner, 1870).

Stern's injection is made with 2 parts of sublimate and 20 of salt to 1,000 of water, and this does not precipitate albumen, and is a good form (Lancet, i., 1871), but Mr. Cullingworth, after many experiments, obtained by far the best of results with a minimum of local irritation by a solution of bicyanide, using 2 gr. with ½ oz. glycerine and 4 oz. of distilled water (10 min. = $\frac{1}{16}$ gr.)—½ gr. made the gums tender (Lancet, i., 1874). Duncan, of Edinburgh, reports good results from the same (B. M. J., ii., 1874).

The advantages of the hypodermic method are facility of dosage and rapidity of effect, cleanliness, and freedom from gastric irritation, yet the unpleasant results which have sometimes attended it have quite prevented its general adoption.

The **Mercurial Vapour Bath** is the best method of application for some cases especially of syphilitic cutaneous disease. In it calomel or sulphide of mercury is vaporized in conjunction with steam, and becomes deposited as finely divided powder on the body of the patient, as he is seated unclothed over the lamp. Care should be taken that the vapour be not inhaled, or profuse salivation may occur.

LITHIUM, L, = 7.

This metal has not been found native. It occurs in the mineral kingdom as an oxide, chloride, silicate, or fluoride with potassium and aluminium (the lepidolite or rose mica of Bohemia). Bunsen and Matthiessen isolated it by means of electricity (1855).

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Supposed at one time to be found in minerals only, it was named λιθιος, stony, but it is now recognized not only in many mineral waters, but in seas and rivers, vines and many fruits, the ashes of plants, and in most of our vegetable food (Bence Jones).

CHARACTERS.—It is soft, silvery-white, and easily oxidizes: it floats upon water, and is the lightest known metal, the sp. gr. being 0·5936.

COMPOUNDS OF LITHIUM.

LITHIA—OXIDE OF LITHIUM, L_2O, = 30.

CHARACTERS AND TESTS.—Occurs in white granules, forms salts with acids, and has a high power of saturation, 15 parts neutralizing as much acid as 41 of soda or 47 of potash. For uric acid it has a special affinity, and will abstract it from portions of gouty bone and cartilage placed in warm solutions of the drug (Garrod).

The most characteristic tests for lithium are the carmine red colour it imparts to flame, and the two lines which it developes on the spectrum, viz., one bright red line at point 82 of the micrometer, and one pale yellow line at 94. Of substances which resemble it, potassium has its red line at 68, sodium its yellow line at 100, and strontium has an additional line of blue.

LITHIÆ CARBONAS—CARBONATE OF LITHIA, L_2CO_3, = 74.

PREPARATION.—From sulphate or chloride of lithium by adding carbonate of ammonium.

CHARACTERS.—Occurs in white powder, or crystalline grains, having an alkaline taste and reaction: is insoluble in alcohol, but slightly soluble in water (1 part in 100, or about 4 gr. to the ounce): carbonic acid increases the solubility to 5 parts per 100.

LITHIÆ CITRAS—CITRATE OF LITHIA, $L_3C_6H_5O_7$, = 210.

PREPARATION.—By dissolving the carbonate in citric acid, evaporating the liquid, and drying and pulverizing the residue.

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CHARACTERS.—A white amorphous powder, anhydrous, deliquescing on exposure, entirely soluble in two and a half times its weight of water: it is somewhat unstable in composition, and requires to be carefully kept from the air.

Some other compounds of lithia are likely to be used, but are not officinal.

The *urate* is very soluble, more so than the urates of potash or soda.

The *benzoate*, which is prepared from the carbonate by adding benzoic acid to the hot solution (Pharm. Journ., July, 1875), occurs in glistening, pearly scales, of soapy feel, acid reaction, and cool, sweetish taste: it is soluble in three and a half parts of cold water, and ten of alcohol—it is thus more soluble than the carbonate, whilst it is more stable than the citrate, and has the advantage of containing an acid itself valuable in the treatment of urinary deposits.

A *ferruginous benzoate* of lithia has been prepared by M. Tréhyon (Progrès Médicale, July 25, 1874) and is recommended both as a non-irritant form of benzoic acid, and as a tonic and preventive of the anæmia produced more or less by all alkalies.

The bromide may be prepared by direct combination, and obtained in transparent crystals which are deliquescent. It contains a large proportion of bromine (92 per cent.), whilst the analogous salt of potassium contains only 66, and of sodium 78 per cent. (S. Weir Mitchell, Amer. Quart. Journ., Oct., 1870). The salt is used for photographic purposes.

ABSORPTION AND ELIMINATION.—Lithia salts are rapidly absorbed: thus, from the experiments of Dr. Bence Jones, it appears that if 3 gr. of the chloride be given to an animal on an empty stomach, it may be detected even in the cartilage of the hip-joint, and the aqueous humour of the eye in a quarter of an hour: 7 gr. having been given to a parturient woman eight hours before delivery, lithia was afterwards detected in every part of the umbilical cord, and 20 gr. of the carbonate having been taken three and a half hours before an operation for cataract, ample traces of lithia were detected in the lens when removed: four days afterwards, lithia could still be detected in

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the secretions, and was not wholly eliminated till the end of seven days (Lectures, p. 16). It is excreted chiefly by the kidneys.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Lithia salts act much like the alkalies upon the gastric secretions,—the carbonate especially is a direct antacid. Small doses are readily borne, but doses of 30 to 50 gr. of carbonate—such as were used by Charcot—give rise, after a few days, to cardialgia and dyspepsia (Note to French edition of Garrod on Gout). Rabuteau also states, that though he, at one time, recommended 15 to 30 gr. per diem, his later experience proved that dyspepsia and even vomiting were caused by these quantities. Climent records similar results in his own person (Traitement de la Gravelle, etc., Thèse, Paris, 1874), and although lithiated waters—*e.g.*, at Baden-Baden—at first improve appetite and digestion, they quickly give rise to sickness and diarrhœa if taken in excess (Althaus).

Circulatory System.—Carbonate of lithia increases the alkalinity of the blood more quickly than potash or soda compounds (Garrod). The same salt, given in large doses (80 gr.), rapidly diminishes the number of red blood-corpuscles, and induces anæmia, like the alkaline carbonates (Climent, op. cit.). A much less quantity than 80 gr. seems to exert a depressant effect on the heart in weakly subjects—lithia in this respect, again, resembling potash in its action—but it does not depress so much as that salt (Garrod). Several observers agree in the conclusion that bromide of lithium, a salt with especially sedative powers, exerts a less lowering effect upon the heart than bromide of potassium (Roubaud, Archives Gén., i., 1875, Lévy, Thèse, Gaz. Méd. de Paris, 1875, No. 27), but frogs and some warm-blooded animals may die under toxic doses of lithia, with cardiac arrest in diastole (Husemann, Hesse).

Nervous System.—Lithia is said to depress the general nerve-power, and a slight degree of tremor or twitching has been sometimes noticed under its continued use, but I am not aware of any serious effects of this kind.

Urinary System.—The quantity of urine is generally increased under lithia, but analyses are not uniform as regards solid urinary products. Thus, M. Levy, using the bromide of

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lithia in gouty subjects, found the excretion of urea and uric acid rather lessened (Gaz. Méd. de Paris, Nov. 27, 1875). In healthy subjects, however, Moss found both liquid and solid constituents much increased (Amer. Journ., April, 1861). Diuresis is usually a marked effect of lithia. One or two doses of 1 to 4 gr. may not produce it, but if continued they do so, and commonly render soluble any urate deposit. In some persons one bottle of lithia water (about 4 gr.) will cause copious secretion, but the effect varies somewhat, possibly according to the amount of acid in the system. Dr. Garrod found lithia more active in this respect than potash, 20 to 30 gr. of the former citrate equalling 2 to 3 dr. of the latter. Moss corroborated this (loc. cit.)

Benzoate of lithia seems to have special powers in this respect, for it is very soluble, and the benzoic acid, changing in the system into hippuric acid, combines with alkalies to form hippurates, which are more soluble and more readily eliminated than urates. The diuretic action of any salt of lithia is much increased by free dilution.

SYNERGISTS.—Lithia is akin to potash, soda, and alkaline earths generally, but the characters of some of its salts indicate a special chemical analogy with magnesia. Thus, the carbonate is decomposed by heat, requires 100 parts of water for solution, but is more soluble in presence of carbonic acid: the phosphate is insoluble, the chloride and nitrate are deliquescent; there is no alum or bisulphate of lithia. Agents promoting waste, such as mercury and the iodides, also favour the constitutional action of this and allied medicines.

ANTAGONISTS AND INCOMPATIBLES.—Acids, acidulous and metallic salts.

THERAPEUTICAL ACTION.—*External.*—Gouty Concretions—Stiff Joints.—These may often be well treated by a lotion containing about 5 gr. of any soluble lithia salt in the ounce of rose-water, kept constantly applied on lint, covered with oiled silk. I have generally combined this application with the occasional local use of iodine and the internal giving of lithia, and have known the concretions and the stiffness to be

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removed. A pomade containing oleo-stearate of lithia has been recommended for friction in similar cases (Duquesnel). Lithia lotions are useful also if the skin be broken near gouty joints. Such sores do not readily heal, because the urate of soda permeates the connective tissue near them, and an alkaline salt neutralizes the acid and promotes healing.

THERAPEUTICAL ACTION.—*Internal.*—Gout.—The treatment of gout varies somewhat, according to the acuteness or otherwise of the attack. During acute gout, lithia is often useful as an adjuvant or an alternative to alkalies, colchicum, etc., but it is during the intervals, when the urine is loaded and the joints obscurely painful, that the habitual use of small quantities is most advantageous. According to Dr. Garrod it lessens the frequency of the attacks, diminishes uric acid deposits, sometimes causes the absorption of concretions, and even wholly removes the gouty dyscrasia. Reasoning from the power of lithia in warm solution to dissolve uric compounds out of gouty bone external to the body, he presumes that it can exert an analogous effect within the system, and favour the elimination of the *materies morbi* in the form of urate of lithia. Wagner found, after ample experience, that treatment by lithia shortened the duration of acute attacks, and prolonged the intervals of freedom: it relieved pain and promoted elimination by diuresis. He gave from ½ to 5-gr. doses of the carbonate in an aromatic bitter, continuing them during the interval between the attacks for many weeks (Schmidt's Jahrb., i., 1875, p. 232). Stricker reports a case in which gouty concretions on the finger-joints disappeared in a few weeks under a course of lithia (quoted by Garrod). Ditterich, whilst estimating the remedy highly, would restrict its use to chronic forms of gout or chronic illness of any kind, if dependent upon excess of uric acid. He found that doses of 5 to 10 gr. were liable to induce dyspepsia, and recommended not more than 1½ gr. for a single dose, or 15 gr. in twenty-four hours: he generally observed relief in seven to fourteen days without drawback (Schmidt's Jahrb., Oct., 1870). When acidity of stomach is present, the carbonate should be given, because it is a more direct antacid than the other salts; if, however, there is no marked gastric derangement, the neutral

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citrate is to be preferred. It is decomposed within the system, and eliminated as carbonate in the urine. The ferruginous benzoate of lithia is much recommended by Dalkiewicz in his essay (Sur la Goutte, 1873), by Malley, and other French physicians (Med. Record, Nov., 1874).

The Baden-Baden waters, though very useful in gout and in gouty headache, concretions, etc., are said to increase the joint pains during their early use (Althaus). There is only one spring, the Murquelle at Baden-Baden, which is distinguished for a considerable quantity of lithia, viz., 0·4 gr. of the chloride of lithium in 16 oz. Next to the Murquelle is the Fettquelle, in the same place, with 0·23 gr. of chloride of lithium, and a spring in Elster, with 0·76 of carbonate of lithia (Braun, p. 479).

With the exception of Dr. Garrod's writings, there are but few English observations on the treatment of gout by lithia, though the remedy must be largely used. It does not always give the satisfactory results that have been claimed for it, and some practitioners are still sceptical as to its real value.

Uric Acid Gravel—Calculus.—When this occurs, independently of distinct gouty attacks, lithia salts, amply diluted, often act well, rendering the "gravel" soluble and the urine clear. According to the observations of G. de Mussy and others, the bromide of lithia exerts a high degree of solvent or lithontriptic power (Roubaud, Archives Gén., 1875).

Lithiated injections into the bladder for direct solution of uric concretions were proposed by A. Ure and Aschenbrennen. The former observer ascertained that an oxaluric calculus placed in a 4-gr. warm solution of a lithia salt lost 5 gr. in weight in five hours, but his practical application of this knowledge to the treatment of calculus within the living bladder has not proved very satisfactory. The patient got some temporary relief from the lithiated injections, and they were presumed to have softened the calculus, but did not reduce its size. Lithotrity was performed, but ultimately the man died (Lancet, ii., 1860). Mr. Ure directs attention to the necessity of avoiding lithia when phosphate of soda is present in the urine, otherwise an insoluble triple phosphate is formed.

Gouty and other Neuroses.—In the forms of irritative

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or melancholic nerve-disorders which sometimes accompany the uric acid diathesis, and in some forms of hysteria, the bromide of lithia promises to be extremely useful. The observers already quoted agree in attributing to it a marked sedative effect on the sensory nerves, and upon the spinal cord, and reflex sensibility, without much depression of the circulation: its action, in short, is more that of bromine than of lithia.

Epilepsy.—In true epilepsy, bromide of lithia was used by M. Lévy and by Dr. Weir Mitchell. The latter physician found that it was determined to the skin much like other bromides, but it proved a better hypnotic, and in moderate doses of 10 to 20 gr., relieved or cured epilepsy after larger doses of other bromides had lost their effect (Amer. Quart. Journ., Oct., 1870).

Acute and Chronic Rheumatism.—I have used lithia salts in these disorders, but with indifferent result.

Croup and Diphtheria.—Foerster, of Dresden, has recommended inhalation of a vaporized solution of carbonate of lithia as a solvent of the false membranes in these diseases.

PREPARATIONS AND DOSE.—*Lithiæ carbonas:* dose, 3 to 6 gr. (B.P.). German physicians recommend less than this. The diuretic effect is increased by free dilution, and the liquor lithiæ effervescens, B.P., which contains ½ gr. to the ounce, is a good form: dose, 5 to 10 oz. *Lithiæ citras:* dose, 5 to 10 gr. (P. B.). I recommend less than these doses. *Bromo-citrate of lithia* in an effervescent water, containing also potash and soda, is prepared by some London chemists (Lancet, i., 1874); also a "granular effervescent citrate," which is a convenient and portable form, and contains 4 or 5 gr. in each drachm. *Urate and benzoate of lithia:* dose, 1 to 4 gr. *Bromide of lithia* (as a nerve sedative): dose, 10 to 20 gr. *A lotion* should contain 4 or 5 gr. of any soluble salt in each ounce. *A vesical injection*, 20 or 60 gr. of a soluble lithia salt in 4 oz. of water.

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MAGNESIUM, Mg, = 24.

This metal is not found native, but may be isolated by decomposing its chloride with potassium or sodium. In combination it is widely diffused, a carbonate occurring in magnesite and limestone rocks, a sulphate and chloride in sea-water, in many mineral waters, and in almost all spring-water: a silicate forms talc, meerschaum, etc., and is present in small quantity in all soils, whence it passes (mainly as a phosphate) into plants and animals.

CHARACTERS.—Magnesium is white, lustrous, hard, and very light (sp. gr. 1·74). It readily oxidizes, and when lighted burns with intense brilliancy.

COMPOUNDS OF MAGNESIUM.

MAGNESIUM OXIDE—MAGNESIA—MAGNESIA LEVIS—LIGHT MAGNESIA, MgO, = 40.

The two oxides, indentical in composition, differ in the arrangement of their molecules, and, consequently, in their weight.

PREPARATION.—By strongly heating the heavy and light carbonates respectively, until all carbonic acid is driven off: hence the name "calcined magnesia."

CHARACTERS.—Magnesia and light magnesia occur as white powders, almost tasteless: the heavier form is called simply "magnesia" and is smoother than "magnesia levis," and more readily miscible with water. A given weight of the light variety occupies three and a half times the bulk of the same weight of the condensed magnesia. (There is no advantage in retaining both in the Pharmacopœia.) Both forms are almost insoluble in water, but their solubility is increased by heat; they absorb water, and if kept long in it, may form a concrete mass of "hydrate." They are soluble in acids.

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MAGNESIÆ CARBONAS—CARBONATE OF MAGNESIA—MAGNESIÆ CARBONAS LEVIS—LIGHT CARBONATE OF MAGNESIA, $3(MgCo_3)MgO\ 5H_2O$, = 382.

PREPARATION.—By dissolving in boiling water, and then mixing sulphate of magnesia, and carbonate of soda, evaporating, and then washing and drying the precipitate. To prepare the *light* variety, the first solution is effected in a *large* quantity of *cold* water, which is afterwards boiled. The result of the decomposition is an oxycarbonate, which is hydrated, and sulphate of soda is removed by washing. Thus:

$$4MgSO_4 + 4Na_2CO_3 + 5H_2O = 3MgCO_3MgO5H_2O + 4Na_2SO_4 + CO_2.$$

CHARACTERS.—The carbonates are white powders, soluble in acids with effervescence. The light form appears under the microscope partly amorphous, with slender prisms intermixed. Their solubility in plain water is slight, but it is much increased by carbonic acid, which converts them into bicarbonates.

MAGNESIÆ SULPHAS—SULPHATE OF MAGNESIA—EPSOM SALTS, $MgSO_4\ 7H_2O$, = 246.

PREPARATION.—By evaporating sea-water or saline springs—also from dolomite, by treating with sulphuric acid: soluble sulphate of magnesia is dissolved out and crystallized, insoluble lime sulphate is left.

CHARACTERS AND TESTS.—Occurs usually in small acicular opaque or whitish crystals, but may be obtained in large, transparent, rhombic prisms. The pure crystals are somewhat efflorescent; but if they contain chloride of magnesium they are moist or deliquescent. Iron is an occasional impurity, and gives a reddish tint to the solution.

The small acicular crystals resemble those of zinc sulphate, with which, indeed, they are isomorphous: they may be distinguished (1) by the taste, magnesia sulphate being bitter and nauseous, zinc sulphate astringent; (2) ammonium sulphide gives with magnesia no precipitate, but with zinc a white one of sulphide (ZnS); (3) caustic potash gives with magnesia a white precipitate insoluble in excess, with zinc, a white precipitate soluble in excess. The rhombic prisms resemble those of oxalic

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acid: the latter are markedly acid to the taste, and are coloured a purplish brown by common ink; magnesia sulphate is not affected by it (except blackened where touched).

ABSORPTION AND ELIMINATION.—Magnesia and its carbonates and neutral salts, such as the citrate and tartrate, are changed into chlorides in the stomach, and absorbed either wholly or in part according to the amount taken and the condition of the gastric fluids (Buchheim and others): not more than 15 gr. at a time is changed (Rabuteau); the unabsorbed portion passes on into the intestine, and under the influence of albuminous secretions, or of carbonic or other acids, especially in the large intestine, an additional amount becomes absorbed, and any residue passes unchanged with the fæces, or under certain circumstances accumulates in the bowel, and forms concretions. Absorption varies with the degree of acidity of the intestinal tract, and if this be not marked, lemonade or other acidulous drinks will be required to secure solution. We need scarcely say that absorption varies also with the nerve-condition (*v.* p. 689). Part of the absorbed magnesia appears in the urine as a triple phosphate.

The sulphate of magnesia, given in *small* doses, is wholly absorbed without producing definite physiological effects. Of large and purgative doses, part only is absorbed, and passes out by the urine or other emunctories. Part of the sulphuric acid of the sulphate is withdrawn by potash and soda salts met with in the bowel, and the magnesia is almost wholly excreted with the motions combined, more or less, with effete bile-products (Buchheim).

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—Magnesia and its carbonate act as direct antacids and local sedatives; also, when given in powder, as mechanical absorbents. A dose of 30 gr. and upwards, given to an adult under conditions favourable for absorption, produces, after eight or ten hours, moderate semi-solid motions, of less than normal odour. It has been stated that the effect of these preparations, though less quickly produced, lasts longer than that of stronger cathartics, and is often more copious, 1 dr. of magnesia causing more evacuation than 1 oz. of Glauber's salt (Trousseau)—also, that their effect increases with continuous use, so that bloody and

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mucous stools may occur after some time. On the other hand, if the drug accumulates in the intestine, mechanical obstruction may be caused by it, and concretions of ammonio-magnesian phosphate, mixed with mucus and débris of food, have sometimes formed when large quantities of magnesia or its carbonate in solid form have been taken; as much as 2 pints (Gubler) and "several pounds" (Brodie) of such concretions have been found in the colon, and Dr. G. de Mussy required a mallet and chisel to remove one from the rectum (Med. Times, ii., 1879).

Peritonitis and even perforation have followed from such obstruction, and I have myself seen one fatal case of the kind. The patient was an actor, accustomed to hurried, irregular meals, and to consuming large quantities of magnesia (for constipation), and on making a post-mortem examination the large intestine was found blocked up by magnesian concretions.

(When a moderate degree only of such a condition is suspected, full doses of vinegar deserve a trial.)

The citrate of magnesia acts as a mild, but efficient and somewhat quicker laxative, and being more soluble than the oxide or carbonate, is free from risk of concretion.

The sulphate, in small doses, acts as a gastric sedative, and if not sufficient to purge, often exerts a diuretic effect, especially if the skin be kept cool: 1 to 2 dr. freely diluted, and taken on an empty stomach, will usually produce several watery stools without colic but with some distension, rumbling, and sense of chilliness. The bitter, unpleasant taste, if uncorrected by carminatives, may induce nausea and debility, but these symptoms subside when the purgative effect commences. The pulse and temperature are lowered by the action, and some malaise may be felt from it; more or less subsequent constipation will also be noticed: the biliary secretion is not increased by it (Rutherford).

Much larger quantities (1 to 2 oz.) are sometimes taken by ignorant or careless persons, and if given to the weakly may cause serious depression, amounting to syncope, with or without severe purging: Christison refers to a fatal issue from a dose of 2 oz. On the other hand, it has been stated that minute quantities (1½ gr.), given by hypodermic injection, will induce characteristic serous motions (Luton, Gaz. Hebdom., 1874), but Caville could not verify this result on dogs, and Professor

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Gubler's trials resulted only in local abscess, so that we cannot depend on Luton's method.

It is, however, ascertained that when even large doses are injected into the veins, no purgation is caused (Moreau, Rabuteau), but rather constipation, and this fact bears upon an explanation of the medicine's action. [Cl. Bernard has stated that the intravenous injection of soda sulphate causes as much purging as its internal administration (Leçons, p. 85), but later observers are very clear as to the contrary.]

Theory of Action.—Poiseuille, and also Liebig, taught that the purgative action of salines when taken by the mouth was due to osmosis of serum *from* the vessels *into* the intestine, and in support of this view Moreau found that on including a portion of intestine (of an animal) between two ligatures, and injecting into it a drachm of Epsom salts dissolved in a little water, afterwards returning the intestine to the abdominal cavity, a large quantity of fluid was poured into the ligatured portion within twenty-four hours (Archives Gén., 1872). Vulpian corroborated these observations, but noted also intestinal catarrh, which others have not done (Gaz. Hebdom., May, 1873). Dr. Lauder Brunton has recorded, in an interesting paper, results similar to those of Moreau (Practitioner, vol. xii.). By means of ligatures he made three loops of intestine, and injecting into the middle one a measured quantity of water with a few grains of magnesiæ sulphas, and into the others the same amount of water only, found, after a few hours, that the middle one contained treble the quantity of fluid injected, whilst the others were empty. He experimented also with *concentrated* solutions passed into the middle loop, always with similar result, and suggests that it is produced by a *direct stimulation* of the intestinal mucous membrane. Rutherford and Vignal also consider the drug a pure stimulant to the same membrane; this, however, was not found congested in the experiments, and although Brunton thinks that the structure of the intestine renders the osmotic theory unlikely, I believe that it best explains the facts with which we are acquainted.

For instance, constipation occurs if sulphate of magnesia be injected into the veins, and it may be presumed that an osmotic current is then directed *from* the bowel *to* the blood, and thus

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the intestinal contents are deprived of ordinary moisture: also constipation results from taking (by the mouth) *small* doses of 5 to 10 gr., and these may be supposed to become absorbed *quickly* into the circulation, and to act as if directly injected into it (as just described): again the purgative effect of full doses (draining off fluid) is followed by constipation. (Rabuteau explains this last fact by supposing a small portion at first absorbed, and producing its physical (endosmotic) effect several hours afterwards, but I think it more probably a natural reaction connected with loss of fluid and empty condition of intestine.)

Some eminent writers, chiefly German, have offered other explanations which require a brief notice. Radziejewski observed, in experiments on animals, that the fæces were quite liquid when passing from the small to the large intestine, and argued that saline purgatives simply *hurried them through* in this liquid state, and that the larger quantity of fluid in stools procured by purgatives could not come from the blood, or even the glands, because on analysis the proportion of albumen in them was found too little for such a source (Reichert's Archiv, 1870, 39, 77). Thiry, experimenting with the peculiar form of intestinal fistula devised by himself, and formed by a separated portion of bowel communicating with the external surface of the abdomen, found that although local irritation would excite secretion in it, saline purgatives, such as soda sulphate, would not do so, and concluded, with Radziejewski, that they simply *increased peristalsis*. Buchheim taught that besides this, on account of their low diffusion-power, they did not readily pass through the intestinal membrane, but, remaining in the canal, retained the water in which they were given, and also much of the natural watery secretion from liver, pancreas, and glands (a very large quantity, according to Kühne), and so carried from the intestine a large quantity of fluid without necessarily drawing it from the blood by endosmosis, or from the glands by stimulation. These reasonings, although ingenious, seem to me answered or qualified by the later experiments of Moreau and of Brunton. Thiry's fistula disarranges normal structure too much to furnish a strong basis for hypothesis, whilst Legros and Onimus have satisfied us that peristalsis *per se* is but little increased by sulphate of magnesia (Journ. d'Anat., Robin, 1869). The

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purgative action of salines is not, however, a mere physical occurrence, the same in any membrane, living or dead; it implies integrity of nerve-supply, for Moreau found that no endosmosis occurred in an intestinal loop if he divided its connecting nerves.

Urinary System.—Magnesia has sometimes caused the solution of uric acid deposits when alkalies have failed to do so, and Mr. Brande pointed out that it could render the urine alkaline, more permanently, if more slowly, than potash or soda. Thus, 2 dr. of soda gave a maximum of alkalinity in a quarter of an hour, 1 dr. of magnesia only at the end of six hours, and ½ dr. in twelve hours (Philos. Trans., 1810). A deposit of triple phosphate occurred, but since earthy salts can be passed in only limited quantities in the urine (Neubauer and others), it is of interest to know precisely how magnesia rendered the secretion alkaline. Caulet concluded from recent researches that both it and lime do so only *indirectly* through the digestive organs—*i.e.*, they neutralize a part of the acid of the gastric juice, and consequently more soda is excreted with the urine, and becomes the direct agent in determining its alkalinity. In support of this, he finds on analysis no increase in the amount of earthy salts in the urine (rendered alkaline under administration of magnesia), but marked excess of soda (Bull. de Thérap., 1875). In further support of this observation, we have the fact that during normal digestion, when the acid of gastric juice is being neutralized and withdrawn from the system, acidity of urine becomes less, and in some stomach-disorders is even replaced by alkalinity (Roberts, Jones).

An observation from comparative anatomy is also of interest. If much lime or magnesia were to be excreted by the urine in conjunction with uric and phosphoric acid, the insoluble salts formed would render the secretion *solid*, or nearly so, as it is in birds and reptiles. Such a secretion would not readily pass through the narrow urinary channels of the human race, and therefore *alkaline earths* pass out rather through the bowel, whilst in herbivora, the urine of which must be fluid and yet contain much earthy salt, the *acids* are excreted by the bowel (Caulet).

Glandular System.—Some observers have attributed to magnesia an alterative action, and Grange, Bouchardat, and

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others state that its habitual use, as in drinking water, will cause goître. Some support is given to this idea by the fact that enlargement of the thyroid gland in mice has followed after mixing magnesia with their food (Gubler), but on the other hand, many waters from goîtrous districts have been analysed without finding in them a trace of magnesia (Med.-Chir. Rev., i., 1862, p. 512).

Toxic Action.—Jolyet and Cahours report magnesian sulphate to be the most toxic of neutral purgative salts, 30 to 90 gr. having caused sudden death in dogs, when injected into the veins. Vulpian noted abolition of voluntary and reflex movements in a frog poisoned by the salt, and its effect has been compared to that of curare, but this comparison requires further support before it can be accepted (Archives de Physiol., Fév., 1869).

Synergists.—Absorbent substances, such as charcoal and manganese, aid the mechanical effect of magnesia in powder. Its purgative effects are aided by acids, by the sulphate and citrate of magnesia, and other neutral salts. It is usual to combine the sulphate and carbonate in a mixture, but unless care be exercised they are liable to form lumps which are not readily soluble. The analogues of sulphate of magnesia are the sulphates, phosphates, tartrates, sulphovinates of potash and soda, and the chlorides of sodium and magnesium. Water, cold, and refrigerants generally are other adjuvants of its action. Dr. Laycock found quinine aid the purgative effect of magnesia sulphate, 1 gr. of quinine with only 1 scruple of the salt, given every three or four hours, acting as well as much larger doses given without the tonic: he supposed this to depend upon improvement of nerve-power (Med. Times, i., 1863, p. 54).

Antagonists and Incompatibles.—Acids given with magnesia destroy its absorbent powers, though increasing purgation; on the other hand, alkalies antagonize its purgative effects by neutralizing gastric acidity. Alcohol, aromatics, and opium lessen its anti-febrile and depletory effects. With regard to opium, Buchheim and Wagner observed that if it be brought in contact with mucous membrane before the saline, no increased flow of liquid occurs, but liquid is absorbed from the membrane:

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they concluded that opium favoured the absorption of the salt, but we hold rather that it acted like Moreau's section of the nerve-supply—narcotizing the terminals, dulling the sense of irritation, and so preventing a flow of liquid *towards* the part—whilst absorption *from* it went on as usual (Gubler).

Magnesia as an Antidote to Arsenic, Cobalt, and Phosphorus.—Magnesia forms a rather insoluble salt with arsenious acid, and is ordered in the German Pharmacopœia as part of the officinal "antidotum arsenici."[1] Schroff proved magnesia to possess antidotal powers in cases of poisoning by arsenic and cobalt, if given early (Med.-Chir. Rev., i., 1859). Sugar and magnesia mixed together have been found useful (Lancet, ii., 1873, p. 157). Orfila proposed it as an antidote to phosphorus, and there is some but not conclusive evidence in its favour (Med.-Chir. Rev., i., 1857).

THERAPEUTICAL ACTION.—*External.*—Magnesia being smooth, light, non-irritant, and antacid, makes a good absorbent dusting powder. It has been used for erythema, erysipelas, and similar inflammatory conditions of the skin, and also for atonic ulcers, exposed surfaces, and inflamed wounds.

THERAPEUTICAL ACTION.—*Internal.*—**Dyspepsia.**—In acidity, pyrosis, and allied symptoms of irritative dyspepsia, such as heartburn, flatulence, colic, or constipation, magnesia and its carbonate are very useful, and their efficacy may be increased by the addition of bismuth or of carminatives: such symptoms are often brought on by food containing too much fat, and this point should be attended to. Headache, accompanied with nausea and mental depression, often occurs in the conditions described, and may be relieved by magnesia. When vomiting is a troublesome symptom in the dyspepsia either of children or adults, and in the vomiting of pregnancy, magnesia often acts well. An effervescent solution of the carbonate or

[1] Seven parts of magnesia mixed with 120 parts of water are to be kept in one bottle, and 60 parts of liquor ferri persulphatis, with 120 of water, in another bottle. The two preparations are mixed only at the time of their being required: hydrated peroxide of iron is precipitated, and sulphate of magnesia remains in solution—4 to 6 dr. of this should be given every quarter of an hour in warm water (Binz).

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citrate is a good form, but 5 to 10-gr. doses of the sulphate will sometimes act better. I have known this succeed in the vomiting of albuminuria, and in cases where hepatic derangement was more marked than acidity.

Acidity and Diarrhœa of Children.—The mild antacid and laxative action of magnesia, and its slight taste, render it a very suitable remedy for the acidity of stomach which so readily occurs in children; it is valuable both when constipation is present, and when unwholesome food has caused irritative diarrhœa (marked by red furred tongue, and greenish, sour, and liquid motions): 2 to 10 gr. of the carbonate may be given thrice daily, its antacid action only being desired, and its purgative effect avoided, unless with the first dose. On several occasions I have known 4 gr. severely purge an infant at the breast. When the attack is clearly traceable to unsuitable food, "Gregory's powder," containing rhubarb and ginger, with the magnesia, is a popular and very useful combination.

Constipation.—In the constipation of delicate persons, especially of pregnant women, also of those subject to gout or rheumatism, hæmorrhoids, or other rectal affections, magnesia is a valuable mild laxative; if required frequently, it should be taken in solution (fluid magnesia), and with lemon-juice, if the system be free from acidity. The citrate or the sulphate are useful aperients at the commencement of a febrile attack of almost any kind, their action being rapid and more or less depletory; the former may be given effervescing in mild cases, but when a full and decided effect is desired, 1 or 2 dr. or more of the sulphate should be used; sometimes it is given in lemonade or acid infusion of roses, but general experience has proved that it acts best with tincture and infusion of senna. In habitual constipation ½ to 1 dr. given in a glass of lemonade or aromatic water, in the early morning, will often answer every purpose. Dr. Fleming found the addition of small quantities of atropia advantageous (B. M. J., ii., 1865): it is more usual now, and I believe better, to make use of the magnesian salts in *combination* with others, as they are found in many natural mineral waters, such as Seidlitz, Pullna, Friedrichshall, or Hunyadi Janos, half a glass or a glass of such waters being ordered with warm water in the early morning. To obviate constipation

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and headache during the use of astringent tonics, moderate doses of the sulphate may be usefully added to medicines containing sulphate of quinine, iron, acids, etc.

Obstruction.—In cases of intestinal obstruction dependent upon hardened fæces, full doses of the sulphate, freely diluted and given every four hours, often succeed well; sometimes the action may be favourably assisted by belladonna.

Plumbism.—In cases of colic and constipation dependent upon lead-poisoning, sulphate of magnesia is a valuable agent; it should be used in conjunction with iodide of potassium, and Dr. Lauder Brunton has well shown that if the latter remedy removes from the tissues the metal in soluble combination, yet it is readily reabsorbed unless the bowels be freely and regularly moved (Practitioner, vol. xii.) : ½-oz. doses may be required. Dr. Copland and others used the sulphate with sulphuric acid before the special value of the iodide was known.

Jaundice.—Although the sulphate has no specific cholagogue action, it is a very suitable aperient in cases of jaundice. Dr. Budd recommends it in combination with the carbonate and aromatics, but I generally prefer one of the mineral waters before mentioned.

Diarrhœa.—In intestinal irritation and diarrhœa dependent upon unwholesome food, and especially stone-fruit, sulphate of magnesia is a good evacuant, because it produces so little irritation. In cases of severe dysenteric diarrhœa from this cause I have often given drachm doses at intervals of six hours, for three or four doses, with the best results.

Enteritis—Dysentery.—Dr. H. Wood speaks of the sulphate of magnesia as the best aperient in enteritis and colitis, when one is required : (usually treatment by opium is to be preferred).

In true dysentery there is much evidence as to the value of the same salt, although it is not generally known. Trousseau called attention to it in 1826 (Archives Gén., v., xiv.), Giacomini recognized it (Treatise on Mat. Med.), and Stillé confirmed their observations : he gave about 60 gr., freely diluted, every two hours, with the result of at once diminishing tenesmus and bloody discharges, and inducing watery feculent stools : the treatment should be commenced early, and is best suited for

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sthenic cases: an occasional opiate at night may be given during the treatment. That the same method is equally available for chronic and debilitated cases is shown by the experience of Mr. Ford in Melbourne, when dysentery was for a long time epidemic and more severe in character than he had ever seen it in this country. Some of his patients (medical men and others) had suffered for many months, with only temporary relief from chalk mixture, laudanum, etc., when he gave them drachm doses of the sulphate, with 20 min. of sulphuric acid, every four hours, and a blue pill, with opium (1 gr.), at night. Mustard was applied over the abdomen, and farinaceous diet ordered. In the course of twenty-four to thirty-six hours, the dejections became feculent, with less blood, and in about nine days all irritation had usually subsided. Mr. Ford adopted this method on the hypothesis that excessive action prevailed in one part of the intestine (the colon), while the rest of it was inactive; and he hoped to "restore unity of action," and also to "eliminate morbid material." However this may be, he is able to report that, in seven years of extensive practice, he did not lose one case of dysentery in the adult (Australian Journ. and Ranking's Abstract, i., 1859).

Hæmorrhage.—Sulphate of magnesia is a valuable adjunct to astringent remedies for hæmorrhage, because it helps to lessen arterial tension and capillary congestion at the same time that it obviates constipation. In *menorrhagia* it may be given with sulphuric acid; in *hæmoptysis*, with ergot, acid, and digitalis (H. Dobell); and in *hæmatemesis*, with alum and opium (Barlow).

Dysmenorrhœa.—In delayed and obstructed menstruation, when the discharge is scanty, dark, and of glutinous character, I have long prescribed the carbonate of magnesia with beneficial results, and especially when the irregularity is attended with sick headache and mental depression; it is most indicated in rheumatic subjects. Five to sixty or ninety grains may be given, according as to whether the constitutional, the laxative, or fully purgative action is required. The small dose should be given each night for the first fortnight after the cessation of the menses, and the larger doses during the latter fortnight, or especially before or during the period, or when headache and depression are present.

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Lithiasis—Uric Acid Diathesis.—The power of magnesia to dissolve uric acid and to lessen its formation, whether directly or indirectly, has already been mentioned. Amongst other instances, Mr. Brande records that of a man, aged sixty, accustomed to pass much uric acid, and even calculi, and who had taken daily either 9 dr. of "subcarbonate" of soda, or 3 of potash, for more than a year without good effect, yet under the use of 60 gr. of magnesia thrice a day the acid soon diminished in amount, and after three weeks of continuous treatment it seldom recurred. Since Mr. Brande's memoir (1810) the remedy has been often used in similar cases. Sir B. Brodie combined 6 gr. of magnesia with 12 of potash bicarbonate and 15 of bitartrate, and it often acted well.

Chronic Gout.—Magnesia, in combination with its sulphate, and sometimes with colchicum in addition, was largely used by Sir Charles Scudamore, and with satisfactory result. It is especially adapted for the gastric derangements to which gouty patients are liable. In rheumatism its value is not so evident.

Diabetes.—In this malady, magnesia has been found useful by Hufeland, Willis, and others. It can only be considered as a palliative of some symptoms.

Warts.—Several curious observations have been recorded to the effect that warts disappear after a few weeks' use of carbonate of magnesia.

Irritant Poisoning.—As already mentioned, magnesia carbonate forms nearly insoluble compounds with arsenic and cobalt, and besides being used as an antidote to those poisons, it has been given with more or less success in cases of poisoning by corrosive sublimate, mercurial oxide, and salts of copper. It is perhaps best suited to neutralize the action of the strong acids, whether mineral or vegetable, and acts well when mixed with charcoal. When used for oxalic acid poisoning, large quantities must be given to form a basic insoluble salt (Husemann).

PREPARATIONS AND DOSE.—*Magnesia—magnesia levis:* dose, as an antacid, 10 to 20 gr.; as a purgative or adjunct, 20 to 60 gr. or more—4 to 8 gr. will purge an infant at the breast; children of about ten years require 30 to 40 gr. The *pulvis rhei compositus* (Gregory's powder) contains 6 parts with

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every 2 of rhubarb and 1 of ginger. *Magnesiæ carbonas—magnesia carbonas leris:* dose, 10 to 60 gr.; 10 to 20 gr. as antacid, 20 to 60 gr. or more as a purgative. *Liquor magnesiæ carbonatis* should contain nearly 13 gr. in the ounce, but does not well retain this amount. The solutions of Henry, of Dinneford, and of Murray are original preparations of the same active ingredient (about 10 gr. to the ounce), and a convenient "double strength" preparation has been introduced by Kinmond. The bismuth lozenges B.P. contain about 2 gr. of the carbonate of magnesia. *Liquor magnesiæ citratis*, the "limonade purgative" of the French codex, may be taken in doses of 5 to 10 fl. oz. A "granular effervescent citrate of magnesia" is in popular demand, but was proved at a trial under the Adulteration Act a few years ago to be in reality a citro-tartrate of soda (Pharm. Journ., 1873). I believe that an article containing at least some citrate of magnesia is now supplied. Magnesilyne is another form of the same remedy. Rochelle salt has also been found as an adulteration of it (Pharm. Journ., Feb., 1873). In consequence of the high price of citric acid, a formula for producing a meta-tartrate of magnesia has been published (Bulletin, i., 1873). In the same journal, M. Martin records the rather important observation that even carefully prepared citrate, which is perfectly soluble when fresh, is apt to change with age into a subsalt, and to become insoluble. A "boro-citrate," made by dissolving a borate of magnesia in citric acid, has been recommended by Köhler for acid urinary deposits (Med. Times, ii., 1879). *Magnesiæ sulphas:* dose, 10 to 20 gr. for irritable conditions of the stomach, or in combination with astringents or tonics; when given with senna or other purgatives 30 to 60 or 120 gr., according to the frequency of repetition. For diuretic effects 20 to 60 gr., as a purgative in a single dose 2 dr. to ½ oz., according to the habit of the patient. Coffee and infusions containing tannin disguise the nauseous taste. *Enema magnesiæ sulphatis* (contains 1 oz. of the salt with 1 of olive oil, and 15 of mucilage of starch). The *mist. sennæ composita* contains somewhat more than a drachm in each fluid ounce combined with senna and aromatics.

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MANGANESIUM—MANGANESE, Mn, = 55.

Manganese is found in many ores, and generally associated with iron; the most common one is the black oxide, or per-oxide (pyrolusite), which is found abundantly in Great Britain and in various parts of Europe.

CHARACTERS.—Manganese is a greyish-white metal, hard and brittle, of sp. gr. 8. It emits a peculiar odour in a moist atmosphere, or if handled. When pure it oxidizes readily in the air, and hence is kept under naphtha, or in sealed glass tubes; it is dissolved by dilute sulphuric acid.

COMPOUNDS OF MANGANESE.

MANGANESII OXIDUM NIGRUM—BLACK OXIDE OF MANGANESE, MnO_2, = 87.

CHARACTERS AND TESTS.—Occurs in brilliant needle-shaped crystals, or in compact masses, but is usually met with in the shops as a dull, earthy, dark-brown or black powder, which contains iron and other impurities. Treated with hydrochloric acid it causes evolution of chlorine, thus—

$$MnO_2 + 4HCl = MnCl_2 + 2H_2O + Cl_2$$

When heated to redness, it gives off oxygen and leaves a residue of red oxide of manganese—

$$3MnO_2 \text{ (heated)} = Mn_3O_4 + O_2$$

Sulphuretted hydrogen causes in manganic solutions a flesh-coloured precipitate of sulphide.

Manganesii Oxidum Preparatum (*not officinal*).—The prepared oxide is obtained by digesting the powdered black oxide in dilute hydrochloric acid for twenty-four hours, then levigating and drying.

MANGANESII SULPHAS—SULPHATE OF MANGANESE, $MnSO_4 5H_2O$, = 241 (*not officinal*).

CHARACTERS.—Occurs in colourless, or pale rose-coloured, transparent crystals, freely soluble in water.

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The *double sulphate*, the *double carbonate*, and the double *iodide, with iron*, are sometimes prescribed; less frequently such compounds as the *lactate*, *phosphate*, *citrate*, and *valerianate of manganese* (Hannon, Guibert). None of them are officinal.

Permanganate of potash (*v.* p. 727).

ABSORPTION AND ELIMINATION.—Salts of manganese undergo probably the same changes in the stomach as salts of iron, and are absorbed as albuminates, or as chlorides. The metal, like others, is eliminated mainly by the bile and the intestinal tract. W. Turner found distinct evidence of manganese in the urine of a diabetic patient who had been taking permanganate of potash freely for three weeks, showing that it is, at any rate, partly eliminated by the kidneys (Edin. Med. Journ., vol. vi., 1861).

PHYSIOLOGICAL ACTION. — *Internal.* — Circulatory System.—The presence of manganese as an essential element of the corpuscles has been relied upon as a guide to its action, but it seems to be rather an accidental than a normal constituent of the blood. Wurzer, in 1830, first announced its presence, and Millon, Hannon, and Burin-Dubuisson corroborated this, whilst Melsens, Bonnewzn, and others, could find no manganese on repeated analyses; Melsens operated on 7 kilogrammes of blood from twenty-one different persons. M. Glénard analysed in various ways, blood from forty subjects of varying age and sex, and found the metal in one case only. He concluded "that manganese is not an essential element of human blood; it may be found accidentally, but only in minute amount; it does not enter by the lungs or skin, as proved in the case of a miner" (Gaz. Méd. de Lyon, 1854). I have not met with any series of analyses for manganese since those quoted. M. Riche, the latest observer, who finds the galvanic test to be exceedingly delicate, has detected minute quantities in the blood of bullocks, etc., but has not tested human blood often enough to speak with authority (Med. Record, 1877). Bartholow, however, considers the question decided affirmatively, and even gives the proportion of manganese to iron in the red corpuscles (human) as 1 to 20. If this be so, we may agree that the administration of manganese would be likely to improve the

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nutrition and the colour of the corpuscles in a direct manner, but so much as this cannot yet be positively stated from physiological research. That manganese has a similar action to that of iron has been often stated, but must be considered problematical (Husemann), and indeed, the increased blood-pressure caused by the latter is not produced by the former drug.

According to Laschkewitz, the organic salts of manganese, in moderate doses, slow the pulse and the heart-action, and cause lowering of blood-pressure, and paralysis of muscles and nerves, which iron certainly does not. After death from manganese-poisoning the heart is found dilated, and does not respond to electrical stimulation.

Nervous System.—Certain nerve-phenomena, whether direct or indirect, are determined by manganese salts. Toxic doses cause death with convulsions, and ½ to 1 gramme injected into the veins of rabbits or dogs produces cramp and death from heart-palsy, or else faintness and weakness and slower death with fatty degeneration (Laschkewitz). The pupils are dilated, the temperature unaffected. Rabuteau injected a little more than 1 gramme into a vein of the hind leg of a bitch, and at first there were no symptoms, but on the following day tetanic convulsions set in, with trismus and opisthotonos, and death followed shortly afterwards: the white substance of the spinal cord was shrunken, the grey matter congested.

Large doses given for a long period induce effects analogous to those of zinc—progressive wasting and feebleness, a staggering gait, and paraplegia (Bartholow).

Digestive System.—The saccharated carbonate of manganese has no peculiar taste, the sulphate is styptic, metallic, and disagreeable. Small doses (5 to 10 gr.) of these salts are said to promote appetite and digestion, but larger quantities are apt to irritate, and cause vomiting and purging. The oxide, which is gritty on the tongue, is said to exert rather a sedative action on the gastric membrane.

The sulphate of manganese has been especially credited with the power of stimulating the secretion of bile since the observations of C. G. Gmelin, who found in animals poisoned by large doses, inflammation of the stomach, intestines, etc., and "so large an amount of bile poured out that the whole

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tract was coloured like yellow wax." He reported a less degree of the same effect in man, and Mr. Ure also found that 60 to 120 gr. acted as a cholagogue purgative (Pereira). Dr. Goolden took various doses, from 1 up to 30 gr., before any vomiting occurred, but states that as a rule 10 to 20 gr. will cause some nausea and free purging with copious secretion of bile (Lancet, 1840, and i., 1878). Dr. Rutherford, however, failed to corroborate this experience, at least in animals, for after giving 60 gr. to a dog the biliary secretion was at once lessened and severe diarrhœa occurred. After death the mucous membrane of the small intestine was found pulpy, "as if the epithelium had been dissolved by caustic." In another dog a dose of 20 gr. equally caused lessening of bile, although benzoate of soda given afterwards had power to re-stimulate its secretion. Dr. Rutherford concludes that the drug is a powerful intestinal, but not an hepatic stimulant, acting very like sulphate of magnesia (*v.* p. 687). Nitrogenous excretion is increased by it. Poisonous doses induce acute fatty degeneration of the liver, like phosphorus.

SYNERGISTS.—Iron may be considered as allied in action to manganese within the limits of the preceding observations; the two substances are constantly associated in nature. Copper, silver, and zinc have allied effects on the nervous system. Goolden speaks of sulphate of manganese as substitutive for mercury as regards the action on the liver, but this is doubtful. He says also that it aids the action of sulphate of magnesia, and Rutherford has shown some analogy between these two salts.

ANTAGONISTS AND INCOMPATIBLES.—Caustic alkalies and salts of lead, silver, and mercury are *chemically* (not therapeutically) incompatible with manganese. Tannic acid and vegetable astringents are not incompatible, as they are with iron.

THERAPEUTICAL ACTION. — *External.* — Hæmorrhage, etc.—The chloride of manganese and iron has been used by M. Pétrequin, in preference to the simple perchloride of iron, as a local hæmostatic; and in Italy it has been applied to necrosed

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bone, and injected into fistulous tracts and hydroceles (Practitioner, vol. v., p. 375), but it has no proved advantage over other well-known remedies.

Skin-Disease.—The same remark applies to the use of an ointment made with the oxide of manganese (ʒij. to ℥j. adipis), which has been recommended in *scabies* and *ringworm*, and, combined with sulphur, in *porrigo*.

Disinfectant.—Free chlorine is readily and cheaply generated by acting on peroxide of manganese with hydrochloric acid, or by heating a mixture of common salt and peroxide with sulphuric acid and water (equal parts). The former process is recommended in the Swedish Pharmacopœia, 1 part of peroxide (pyrolusite) and 4 of acid being ordered: the latter process is that known by the name of Guyton Morveau: a mixture of manganese oxide 7½ grammes, and 10 grammes of salt, with sulphuric acid and water, of each 20 parts, will disinfect a space of 30 cubic metres.

THERAPEUTICAL ACTION.—*Internal.*—**Anæmia—Chlorosis.**—Manganese was introduced into practice mainly by M. Hannon, of Brussels, with special reference to the treatment of these conditions. He argued that, during digestion, sulphuretted hydrogen is formed, and reacts on the ferrous and manganic compounds contained in the intestine, changing them into insoluble sulphides, and thus removing essential elements of hæmatosin. This happens especially (he supposes) in chlorosis, and the remedy is to supply more of a metal which can form such sulphides, and prevent the removal of essential elements of the organism. Hence, bismuth, lead, and copper are said to prove as serviceable as iron or manganese, though the latter are better assimilated (Presse Médicale Belge, 1850, and Guibert). M. Hannon goes even further than this, and describes three forms of chlorosis, according as there is a deficiency in the blood of iron only, of manganese only, or of both metals. Thus, in the first case, there are "earthy tint of skin, weakness of locomotor system, slow, regular pulse, diarrhœa, and fluid menstrual discharge." In the second case, "colour of skin and mucous membranes normal, pain in muscles, constipation, amenorrhœa." In the third case, "waxy

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tint, bluish sclerotics, œdema, serious nerve-disturbance, derangement of circulation, dyspnœa, low temperature, uterine pain." According to such symptoms does he recommend either iron alone, manganese alone, or a combination of both metals. It is evident that these statements are largely theoretical; and, apart from the fact that even the necessary presence of manganese in the blood of healthy persons is doubtful, an appeal to clinical results does not bear out the suggestion of its great importance as a hæmatinic remedy—rather the contrary. M. Hannon himself reported very good effects from it, and Dr. Steer (Cheltenham) saw benefit in chlorotic anæmia, traumatic anæmia, and in phthisis, and in anæmia of children; but he used saccharated carbonate of manganese with iron, not manganese alone. In uterine leucorrhœa of pale weakly subjects, he gave it with ergot; for constipation, with aloes; for dyspepsia, with soda and rhubarb (Med. Times, ii., 1853). Sir J. Simpson found the phosphate sometimes useful in amenorrhœa, given either with or without iron, but says very little about it (Med. Times, i., 1861, p. 517). Dr. Broadbent, using the chloride and sulphate, reported some favourable, some negative, results. Mr. Carter used it with no good effect (Clin. Soc. Trans.), whilst Dr. Garrod failed to cure every case of anæmia in which he employed the manganese salts alone, and the subsequent administration of iron was always followed by rapid improvement. It is true that M. Pétrequin was an enthusiastic advocate for the remedy in all forms of impaired blood-condition, including intermittent fever, phthisis, and cancer, but the general experience of the profession is not with him or M. Hannon. All we can at present say is, that in obstinate cases of chlorosis not cured by iron, the conjunction with manganese should receive further trial.

Hepatic Disorder.—I have already mentioned that Mr. Ure found 1 to 2 dr. of the sulphate act as a cholagogue purgative (Pereira), and Dr. Goolden gave it in cases of enlarged liver with dark or pale stools, and jaundice, when no abscess or acute symptoms were present. Most of the patients (at the Dreadnought Hospital) were in weak condition, having returned from India, and he sought for a non-mercurial remedy to stimulate the liver. He says that 10 or 20 gr. of sulphate of manga-

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nese, though at first it excited nausea or vomiting, soon acted on the bowels to the marked relief of the patient, and with rapid clearing away of the jaundice (Lancet, 1840). This favourable result has, however, not been corroborated by the experience of others, but recently Dr. Goolden has written to direct attention again to the subject, stating that he has continued to use the remedy with success in hepatic dropsy, hæmorrhoids, bronchial congestion, hypochondriasis, etc.: he usually combines it with Epsom salts, in a glass of effervescent water (Lancet, i., 1878).

Polli and Galamini state that they have cured cases of biliary calculus by peroxide of manganese, given in gramme doses daily as an electuary: they explain the solution of the calculi by the action of oxygen from the peroxide upon the cholesterine (Gaz. de Paris, 1856).

Gastrodynia—Pyrosis.—Dr. Leared found that purified oxide of manganese had decided power in relieving these disorders; he describes epigastric pain, severe and radiating, coming on not immediately, but soon after food, worse after albuminous food; the tongue generally red and patchy, and the malady connected with too rapid shedding of epithelium and exposure of a hyper-sensitive mucous surface; pyrosis and vomiting are sometimes present.

Bismuth is a usual and excellent remedy for such a condition, but Dr. Leared found manganese relieve it often more quickly, with the advantage of not causing constipation. He states that he has treated several hundred such cases with satisfaction, before venturing to recommend it (Ranking, i., 1864). No mention is made of a drawback described by Dr. Goddard Rogers, whose patients found the medicine so gritty and unpleasant that they could scarcely continue it. He reports two cases of gastralgia, "severe pain with occasional vomiting," one case of stomach derangement sympathetic with the uterus, and one of pyrosis, with "irritable mucous membrane." All these got well rather quickly with 10-gr. doses of the oxide (Lancet, i., 1864, ii., 1865). We have not, however, heard much of this remedy from other observers.

PREPARATIONS AND DOSE. — *Manganesii oxidum preparatum:* dose, 5 to 10 gr. *Manganesii sulphas:* dose, 10 to

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20 gr. as a purgative. *Ferri et manganesii carbonas saccharata:* dose, 5 to 10 gr. as a hæmatinic. Solutions of manganese salts are apt to change colour on exposure to the air.

PLUMBUM—LEAD, Pb, = 207.

This metal, rarely found in its native state, occurs more often combined with sulphur or oxygen. Its commonest ore is galena, a glistening grey sulphide, PbS, from which the metal is obtained by roasting it in a current of air; it is not used in medicine.

COMPOUNDS OF LEAD.

PLUMBI OXIDUM—OXIDE OF LEAD—LITHARGE, PbO, = 223.

PREPARATION.—By roasting lead ores with access of air, when the oxide is formed in a melted state, and separates on cooling.

CHARACTERS AND TESTS.—Occurs in small glistening red or yellowish-red scales, which should dissolve without effervescence in dilute acids, but after exposure for some time to the air, the scales slowly absorb carbonic acid and may then give some effervescence; they are soluble also in excess of potash.

The following *tests* are applicable to this, and to all soluble salts of lead:—(1) Sulphuric acid and soluble sulphates give a white precipitate (sulphate of lead) insoluble in dilute acids; (2) Iodide or chromate of potassium gives a yellow precipitate of iodide or chromate of lead; (3) Sulphuretted hydrogen or sulphide of ammonium gives a black precipitate of sulphide of lead, but if the proportion of lead be minute, the colour is brown rather than black (W. G. Smith).

PLUMBI ACETAS—ACETATE OF LEAD—"SUGAR OF LEAD." $Pb(C_2H_3O_2)_23H_2O$, = 379.

PREPARATION.—By dissolving lead oxide in slight excess of acetic acid by aid of gentle heat, then crystallizing.

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CHARACTERS.—Occurs in white crystalline lumps, not unlike sugar, or in large four-sided prisms. The odour is somewhat sweet and acid, and the taste at first sweet, afterwards astringent. It effloresces in air, and is soluble in water; with distilled water the solution is clear, but with ordinary water it is turbid from the formation of carbonate of lead with the alkaline carbonates always contained in such water; a few drops of acetic acid will dissolve the carbonate and clear the solution.

LIQUOR PLUMBI SUBACETATIS—SOLUTION OF SUBACETATE OF LEAD—"GOULARD EXTRACT,"
$Pb(C_2H_3O_2)_2PbO$ (in water), = 548.

PREPARATION.—By boiling neutral acetate of lead with two-thirds of its weight of oxide of lead, then filtering, and adding distilled water: a basic or sub-acetate of lead is formed.

CHARACTERS.—A colourless liquid of alkaline reaction and sweetish astringent taste. It quickly absorbs carbonic acid from the air, and becomes turbid from formation of carbonate. It gives precipitates with most vegetable colouring matters, with tannin, and with many animal substances, especially albumen. With gum it forms an opaque white jelly, which the acetate of lead does not. It answers to the other tests of lead already mentioned.

PLUMBI CARBONAS—CARBONATE OF LEAD—"WHITE LEAD," $2PbCO_3PbO,H_2O$, = 775.

PREPARATION.—No process is given in the Pharmacopœia, but the carbonate is prepared on a large scale by exposing thin sheets or gratings of lead, placed in earthen pots, to the combined action of acetic acid, air, and carbonic acid gas.

CHARACTERS.—A heavy white powder, insoluble in water, but readily soluble in dilute acids, with effervescence.

PLUMBI IODIDUM—IODIDE OF LEAD, PbI_2, = 461.

PREPARATION.—By precipitating a clear solution of nitrate of lead with iodide of potassium, washing, and desiccating.

CHARACTERS.—A bright yellow powder, darkened by heat, almost insoluble in cold water, soluble in boiling water, from

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which it is deposited in golden crystalline scales; soluble in solution of acetate of sodium. It fuses and sublimes yellow, but soon gives off violet vapour (Garrod).

PLUMBI NITRAS—NITRATE OF LEAD, $Pb(NO_3)_2$, = 283.

PREPARATION.—By dissolving lead, or its oxide or carbonate, in boiling nitric acid, slightly diluted, then crystallizing out.

CHARACTERS.—Octahedral crystals of white waxy appearance, and sweetish, astringent taste, soluble in water and alcohol, not efflorescent.

ABSORPTION AND ELIMINATION.—Soluble lead compounds, when introduced into the stomach, are transformed probably into chlorides, but in any case are readily absorbed, as shown by clinical results; it is presumed that they circulate mainly as albuminates.

Workers in lead, such as compositors, plumbers, and painters, absorb the metal in part by the skin, in part by the lungs, and sometimes directly with the food (from eating with unwashed hands), and injurious effects are not uncommon from the application of cosmetics and dyes containing lead, to the skin and hair (*v.* p. 714). Once within the system lead remains for a long time, in small quantities at least, and may be deposited in different organs. It has been found not only in the blood and in the liver, spleen, and kidney, but also in the muscles and bones, and Chatin recovered 3 milligrammes of lead sulphide from 150 grammes of the upper cervical cord—the tissue was dark grey in colour (Comptes Rendues, Soc. de Biol., t. iv., 1862). Lead is *eliminated* chiefly in the form of chloride through the liver, kidneys, skin, and mucous membranes, especially those of the urinary tract; the process is markedly promoted by iodide of potassium.

(It will be seen from the above observations that I cannot accept the conclusions of Mayençon, "that lead is not absorbed by the skin," and that after being taken, "its elimination is prompt and complete"—Med. Times, i., 1873, p. 489.)

PHYSIOLOGICAL ACTION. — *External.* — Solutions of acetate and nitrate of lead, if not too strong, exert a local

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astringent and sedative action, coagulating albumen, contracting the vessels, blanching the tissue, and controlling congestion if present; on the other hand, if the solution be too strong, and be applied to a delicate part, such as the conjunctiva, it excites severe irritation. The carbonate of lead, applied in fine powder, is sedative and slightly astringent. The iodide is slightly stimulant and absorbent. The nitrate and chloride decompose sulphuretted hydrogen, combining with the sulphur, and hence they act as deodorants.

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—The acetate and subacetate of lead are the only salts of this metal given internally, and the effect of moderate medicinal doses upon the intestinal tract is to diminish its secretions and to occasion sometimes slight colic. The more pronounced effects of poisonous doses vary with the mode of receiving them, and may be acute, subacute, or chronic in character.

Acute poisoning. — After a dose of from 1 to 2 oz. the symptoms begin quickly with the characteristic taste of the drug, followed, perhaps, in a quarter of an hour by burning and pricking in the gullet, nausea and vomiting, but the vomiting caused by the poison alone is not usually severe; there is uneasiness in the stomach sometimes followed by violent colic, but the pain intermits, and it may be relieved by pressure. There is usually constipation, but sometimes an attack of purging, the fæces being dark, and containing lead sulphide.

Subacute poisoning may be illustrated by cases which occurred at Stourbridge in 1849, when acetate of lead was mixed by accident with flour at a miller's. Upwards of 500 persons were attacked, a few days after eating the bread, with a sense of constriction about the throat and stomach, cramping pain near the umbilicus, and rigidity of abdominal muscles; sickness occurred only in a minority of the cases, and did not last long; there was obstinate constipation and a general lessening of secretion; a dark blue line on the gums was noted. No cases were fatal, but severe symptoms continued for a long time, and sometimes recurred after apparent convalescence.

The subject of *chronic lead-poisoning* is exceedingly interesting to the practical physician, but concerns us at present only as

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illustrating the physiological action of the drug. Some of its symptoms have occurred from the medicinal use of the acetate, and from the continued use of minute quantities rather than from massive doses. Thus, Sir R. Christison gave 18 gr. in two days without injurious effects, whilst $\frac{1}{15}$ gr. given two or three times daily for two months caused fatal poisoning in a child (Letheby, Taylor). As a rule, it may be said that the worst effects of any medicinal use of lead limit themselves to an attack of colic, and the severe symptoms about to be described need not be feared from it: 5-gr. doses of acetate are largely used at Brompton Hospital without bad results.

The ordinary "lead colic," or plumbism, is traceable most frequently either to the mechanical use of metallic lead, its oxides or carbonates, or to the solution of these salts in drinking-water, etc. (*v.* p. 714). After some general malaise, disordered taste, dryness of mouth, fœtid breath, anorexia, and constipation, pain will usually be the most marked symptom, but is not so invariably; Dr. Garrod finds it absent in 2 to 3 per cent. of cases. When fully developed, it is much more intense than ordinary colic; it is referred mainly to the region of the navel (the colon), but darts rapidly, like neuralgic pain, in many directions, towards the loins, the scrotum, the chest, and the thighs: it has a twisting, tearing character, so that German miners name it commonly "Hütten Katze" ("cat of mines"). It comes on in paroxysms, remaining constant but dull in the intervals, and the whole attack lasting from a few minutes to several hours; it is often worse at night, but its recurrence is irregular. Relief is found from firm pressure and altered position, and the sufferer either lies flat on his face, pressing the abdomen, or is doubled up, bending his legs, or rises suddenly, still pressing the painful part with his hands, till a violent paroxysm again sends him to bed. Restlessness is extreme, and the whole attention is concentrated on the pain. The abdominal walls are rigid, knotty, and drawn in, there is commonly tenesmus, and the rectum has been felt to contract and relax spasmodically. The liver is retracted (Potain) or actually lessened in size; the intestines also are drawn into less space from contraction of their muscular coat, and in prolonged cases, after the abdominal fat has been absorbed, the retraction of the belly becomes very striking.

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Tanquerel (Traité des Maladies de Plomb, Paris, 1839) and Burton (Med.-Chir. Trans., 1840) were the first to describe as common in plumbism a dark blue or grey line along the free edge of the gum, together with a brownish coloration of the teeth. Though a valuable sign, and often present, it is not always so, nor does it necessarily imply saturation of the system with the mineral; it varies in its time of appearance according to the dose, but has been seen within twenty-four hours of administration of one large quantity (Burton): 20 to 30 gr., in divided doses, may develop it, and when once seen it is very persistent; similar coloured patches may often be found on the buccal mucous membrane. The colouring depends on formation and deposition of lead sulphide from the sulphuretted hydrogen evolved from particles of food left about the teeth (Tomes), and by perfect cleanliness it may be prevented. According to Dr. Hilton Fagge, it is distributed in rounded loops corresponding with vascular papillæ of mucous membrane, and depends on small pigmented granules, some of which are external to, others within the small vessels. He concludes that the gas from food-particles diffuses into the gum-textures, and then combines with lead circulating in blood or plasma, so that particles of lead sulphide are really precipitated—a similar condition may be present in the intestinal membrane. Iodide of potassium sometimes induces its rapid development (Lancet, i., 1876, p. 709).

We cannot so readily explain the pathology of the colic. It is in part dependent on constipation, or accumulated mucus within the canal, for it is relieved when purgation is secured; yet Briquet claims to have relieved more quickly by faradaism of the abdominal wall without any aperient effect. It is dependent partly also on irregular muscular contraction of the intestinal tube, following on partial paralysis and spasmodic peristalsis; other characters again show it connected with an enteric neuralgia (*v.* p. 711).

In acute poisoning, the gastro-intestinal mucous membrane has been found coated with a whitish-grey layer of coagulated mucus containing the poison, and there have been patches of abrasion, congestion, or inflammation. In chronic cases the membrane is congested, softened, and discoloured, the walls are thickened, and the canal irregularly contracted; sometimes

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intussusceptions are found; the coils of intestine are closely packed together. In chronic plumbism, emaciation is notable, especially about the face.

Nervo-muscular System.—Ordinary medicinal doses do not usually produce definite effects on the nerves or muscles, but in acute poisoning from large quantities, besides the pain and cramp already mentioned, general prostration is a marked symptom. There may be also giddiness or stupor, numbness or paralysis, and, in fatal cases, convulsion. In the subacute cases at Stourbridge, the nervo-muscular symptoms were cramp and rigidity of muscles, numbness, and partial palsy of lower extremities, and collapse: the mental faculties were unimpaired.

But it is in chronic plumbism that affections of the nerves and muscles become marked and significant, various forms of paralysis almost always appearing. The most common is a paralysis of the extensors and supinators of the forearm, leading to a condition known as "wrist drop," from the peculiar manner in which the hand hangs down when the limb is extended. This occurs more often on the right side than the left—the fingers and wrists are flexed and the hand prone, the elbow stands out from the side, and the forearm bends on the arm—wasting of the affected muscles quickly follows, and especially of the small muscles of the thumb.

A special plastic or fungoid form of synovitis in the sheath of the extensor tendons has been described (Gubler, B. M. J., ii., 1878).

Sometimes other muscles are affected—thus, strabismus has been noted from paralysis of ocular recti, and aphonia from laryngeal palsy. Occasionally hemiplegia occurs, more rarely still paraplegia, and in advanced cases the extensors, at least of the lower limbs, are more or less affected. Death has resulted from paralysis of respiratory muscles. Of the special senses, sight is the most often affected, amblyopia occurring, or amaurosis from anæsthesia of optic nerve; in such cases the pupil is dilated. It is not uncommon for the hearing to suffer, and common sensibility is often altered. There is usually partial anæsthesia, though sometimes, as in the Claremont cases, excessive hyperæsthesia is developed.

During an attack of lead colic the intellect is, as a rule,

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clear, but in continued cases the moral courage and the spirits give way, and sometimes in the course of the illness distinct delirium occurs, generally of the form "delirium of dread," not unlike delirium tremens. The patient is extremely fearful of being alone, especially at night, and has visions of black and creeping things. Three remarkable illustrations occurring in women-workers at a lead-factory are furnished from the London Hospital (Med. Times, i., 1869). Other cerebral symptoms, such as headache, delirium, epileptiform convulsions, and coma, have been recorded; insomnia is usual.

Theories of Plumbism.—Whether the muscles or nerves are primarily affected, and in the latter case whether the peripheral branches or the centres are most at fault, has been much debated. Giacomini attributed the *colic* to direct muscular irritation from deposition of the metal in the abdominal muscles and the diaphragm, pointing out that superficial pressure often gives pain, even over the iliac crests (where the intestines are not), whilst firm supporting pressure relieves. Briquet, acting upon this theory, faradized the skin of the abdomen with a metallic brush, and thus relieved the pain by counter-irritation. That the *paralysis* also depends on deposition of the metal in the muscles is suggested by the frequency with which the right arm is affected in lead-workers, it being more exposed to the poison than the left.

Tanquerel maintained that the colic was due to irritation of the great ganglionic centres, though signs of this could only be found in one out of forty post-mortem examinations. It may be noted, however, that galvanism of the sympathetic nerve-centres has been said to cause elimination of the poison quickly, and to cure palsy of the fore-arm without direct local treatment (Med. Times, i., 1877).

Eulenburg considers lead colic "a mixed neurosis of motor-sensory nature, in which the splanchnic nerves and vaso-motor branches from the aortic plexus are affected" (Med. Times, i., 1870). He points out the special determination of lead to the muscular system and its powerful local effect in causing contraction of involuntary muscles.

Heubel argues that the peripheral intra-muscular extremities of nerves are at fault rather than main trunks (Bleivergiftung,

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Berlin, 1871), and Althaus apparently takes the same view (Med. Times, i., 1874, p. 548). On the other hand, Bernhardt asserts that the real lesion is in the grey matter of the cord (Med. Record, 1878), and most modern observations point to the same conclusion, at least in chronic conditions; lead has been found in its substance in some cases (Chatin, *v.* p. 706), and a granular partly atrophic state of spinal cells has been verified in one instance by Lancereaux. The affected muscles and corresponding nerve-trunks are much atrophied, so that sometimes scarcely one normal fibre can be found.

Circulatory System.—Full medicinal doses of the acetate slightly lower the force and frequency of the pulse (Laidlaw). In hæmorrhagic cases and in pneumonia this effect is often marked. Strohl found a diminution of ten to fifteen beats per minute after daily doses of 25 to 50 centigrammes, and Rabuteau verified a pulse-rate below that of health; it has been explained by a direct action on the muscular structure of the heart. In cases of *acute* lead-poisoning, the pulse has been sometimes quickened, but has become slow in the stage of collapse. In *subacute* cases it is markedly slow and feeble. During a paroxysm of colic in the course of plumbism the pulse is of characteristic wiry hardness, and generally lowered in frequency, while the heart-action is so weakened as to be scarcely perceptible. In half the large number of cases recorded by Tanquerel, the pulse-rate was from 30 to 60 per minute, the hardness and slowness being usually proportional to the amount of pain; exceptionally the frequency was increased. The peripheral circulation is commonly impeded, and arterial anæmia leads to pallor and chilliness, though in two cases recorded by Murchison a rise of temperature (102°) was found (Lancet, i., 1868). In *chronic* conditions of lead-poisoning the pulse is small, hard, and usually slow, and the sallow, bloodless skin has an icteric tint, anæmia is commonly marked, and there is more than normal water in the blood as well as fewer red globules; Malassez states, however, that these are increased in size (Archives de Physiol., 1874). Cardiac murmurs are usual in lead-workers, and it is said that the heart and great vessels have been found smaller than usual after death. Henle considers that the vessels are contracted (during life) by direct irritation of their

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muscular coat by lead circulating with the blood; certainly vascular tension is much increased in plumbism, as clearly shown by the sphygmogram of Dr. A. Frank (Deut. Arch. Klin. Med., Bd. xvi., Hft. 3). German observers, besides corroborating this, have demonstrated the antagonistic effect of pilocarpin during attacks of colic; very soon after its hypodermic injection the tracing shows greatly lessened tension, and simultaneously the pain is relieved. Nitrite of amyl acts similarly (Med. Record, 1876).

Genito-urinary System.—Chronic lead-poisoning often leads to abortion, and if this does not occur, the children born are delicate. Of 123 conceptions amongst lead-workers, 50 children only were born alive, and of these but 14 survived infancy. It would seem that the influence of one parent only affected by lead is enough to produce these results (M. Paul, Archives de Méd., 1860). Amenorrhœa has been clearly traced by Dr. Dowse to working in lead.

The influence exerted by this drug upon the kidney is of great practical importance: albuminuria is not uncommon in acute plumbism, and is then connected probably with altered blood-conditions, but in chronic cases a directly injurious action is exerted on the kidney structure, leading to fatty or albuminoid degeneration. Dr. Shearman has recorded two remarkable instances of albuminuria in one family, clearly traceable to the use of drinking-water impregnated with lead—characteristic palsy was also present. The cases recovered for a time after removing the cause, but later, one died of apoplexy, the other of albuminuria (Practitioner, vol. xii.).

During a paroxysm of colic the kidney secretion is diminished, and is passed with difficulty. It is proved, also, that the withdrawal of urates from the blood in its passage through the kidneys is lessened under the influence of lead, and the amount of uric acid excreted by the same organs is lessened, hence a larger than normal amount remains in the blood, and the patient becomes exposed to gouty attacks. Indeed, both Dr. Garrod and Dr. Ringer have developed acute gout in susceptible subjects by the administration of lead salts, and the former has calculated that 33 per cent. of gouty patients had been exposed in some manner to the action of lead. Pains about the joints,

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and urate deposits, are not uncommon in saturnine cachexia. Dr. Wilks adds testimony to their frequency (B. M. J., i., 1875).

Glandular System.—By the ordinary medicinal use of the drug all secretions are diminished. According to Rutherford, the acetate of lead is the only substance which lessens the secretion of bile without causing purgation, and he considers this action to be direct, not indirect or reflex; it is overcome by salicylate of soda. He connects the constipation partly with this action on the liver, partly with similar action on the intestinal glands (B. M. J., ii., 1878). Heubel attributes the icteric condition frequent in plumbism to contraction of the bile-ducts (muscular fibres). During an attack of colic, all the secretions are diminished except that of the skin (Alderson, Lumleian Lectures, 1852, Lancet).

Modes of Chronic Lead-poisoning.—Of the different workers in lead, oxide of lead, or "white lead" (carbonate), those who grind it in factories are most liable to suffer, though less so now that the powder is ground with water (Taylor); but house-painters and coach-painters, plumbers, pewterers, and compositors, makers of certain white glazed cards, hat pressers, bleachers of Brussels lace, and glazers of pottery, are often affected. Severe symptoms have sometimes arisen from sleeping in a newly-painted room, or from breathing the smoke of burning painted wood. Amongst exceptional and little suspected causes of plumbism, are the handling of vulcanized rubber and black horse-hair coloured by lead sulphide, the use of hair washes, dyes, and cosmetics containing lead salts, breathing dust from "American cloth" whitened with lead salts, and in the process of making yellow cord fusees (chromate of lead). Poisonous symptoms have followed in an infant after the application of strong lead lotions to the mother's nipples, and in children from yellow confectionery (chromate); the chewing of "tea lead" (in which tea is wrapt), the using of snuff that had been wrapped in similar "foil," the use of soda water from lead "syphons" (B. M. J., 1874–75)—(free tartaric acid is said to help in this case)—bathing in water impregnated from a leaden pipe, the drinking of wine from bottles which had been cleansed with shot—have all caused plumbism.

Two curious epidemics have occurred—one at Taunton,

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another in France—from flour ground between mill-stones that had been mended with lead (B. M. J., 1877, Med. Times, i., 1878), and even the handling of lead machines, as in ice-cream making, or cameo polishing, or cleaning "beer engines" or brass handles (as engineers do), has induced colic.

There is some reason to think that the "dry colic," or enteric neuralgia, of tropical countries is connected with lead. Gubler gives instructive instances of its development from the use of lead cosmetics in creoles (Med. Record, 1876), and it is said to have become more common since steam-boats have been more used! (Med. Record, 1876). Mialhe and other French physicians also speak of lead colic being frequent on ship-board, and connect it with the action of a saline atmosphere on lead engines, etc.

But excepting the trades first mentioned, the most frequent source of lead-poisoning is the use of drinking-water impregnated with the metal or some of its compounds. Bad symptoms have resulted from so small an amount as $\frac{1}{40}$ gr. per gallon, and 1 gr. per gallon is a surely dangerous dose. It is to be noted that the freer the water from saline ingredients, the more readily it takes up a soluble carbonate formed on the metal pipe or cistern. Its formation and solubility are also favoured by much organic impurity, free access of oxygen, a little nitric acid (as may happen after thunder-showers), or the presence of a second metal (iron as well as lead). Carbonic acid in pure water also favours solubility, although in certain circumstances it may act differently. Lime and other saline constituents will, on the other hand, if present in the water, *lessen* liability to contamination by forming insoluble coatings on the metal: otherwise, no doubt, plumbism would be still more common than it is.

Idiosyncrasy.—There is a great difference in the susceptibility of different individuals to the poisonous action of lead,—as may be verified in any large factory,—and it is comparable to what has been noticed with arsenical wall papers, etc. One attack of colic strongly predisposes to another, which may follow after a long interval from comparatively slight cause—thus, a man who had suffered as a house-painter, turned gamekeeper, and got an attack long afterwards from stirring shot in water with his hands (B. M. J., i., 1877).

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SYNERGISTS.—The depressing influence of lead upon the circulation is assisted by digitalis, ergot, veratrum, prolonged cold, etc.; its astringent action by metallic salts of copper and zinc particularly. The other metals, especially mercury, antimony, and copper, have a similar effect in lessening nutrition.

ANTAGONISTS AND INCOMPATIBLES.—Sulphate and carbonate of lime, carbonic acid, acids mineral and vegetable, alkalies, iodide of potassium, opium, albuminous solutions, and most vegetable astringents are chemically incompatible, and most of these may be used in the treatment of lead-poisoning. In acute cases, when the drug has been taken by the mouth, emetics or the stomach-pump should be used, and sulphate of soda or magnesia given in milk or mucilage. In chronic cases, alkaline iodide should be given internally, and sulphur baths should be used, containing about 7 oz. of sulphuret of potassium. During half an hour of bathing, frictions should be employed, and soap should be freely used afterwards (Eulenburg). Electricity should be applied to the affected muscles —faradaism if it causes contraction, if not, the continuous current three or four times weekly for about a quarter of an hour, whether it induces contraction or no: in curable cases it will ultimately do so. Purgatives should be freely given. Fatty food is said to antagonize the development of plumbism in lead-workers, and a long prevalent colic in large lead-works at Birmingham was stopped by the free use of a "treacle beer," containing sulphuric acid (Lancet, i., 1860). Washing the hands before eating, etc., is important, and washing with petroleum is said to be prophylactic (B. M. J., ii., 1877).

Pilocarpin and amyl nitrite antagonize the increased arterial tension which occurs in chronic cases (*v.* p. 713).

THERAPEUTICAL ACTION. — *External.* — **Disinfectant Power.**—A solution of lead nitrate (Ledoyen's disinfectant) has been in use for many years, and acts by decomposing sulphuretted hydrogen, but has no other good effect; it is comparatively expensive, and its black precipitate is sometimes objectionable: Dr. Goolden has, however, recently recommended as applicable to many cases, solution of *chloride* of lead, although it

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also can act only on sulphuretted hydrogen. He prepares it by dissolving ½ dr. of powdered nitrate of lead in one pint of boiling water, and mixing this with 2 dr. of common salt in 2 gallons of water. The precipitate which falls is in part carbonate of lime, in part carbonate of lead, and the clear supernatant fluid is a saturated solution of lead chloride. This quickly removes the smell of foul drains, ship-holds, etc., and cloths wrung out of it, and placed about a room, neutralize organic emanations, *e.g.*, from crowded assemblies, fœtid suppuration, etc. It was used with much advantage on board the *Thunderer* after a gun-explosion (Lancet, ii., 1875, ii., 1876, B. M. J., ii., 1876, p. 323).

Inflamed Surfaces.—A solution of subacetate of lead is still, perhaps, the most frequently used of all remedies in the external inflammatory conditions for which it was introduced by Goulard, of Montpelier, more than 100 years ago.

In *erysipelas* it proves cooling and astringent, and a good formula for its use is that given by Christison, Murchison, and others (Med. Times, i., 1867, p. 523), viz., 4 gr. each of lead acetate and of powdered opium in an ounce of warm water. The meconate of lead is formed, and precipitates, but gives an effective therapeutical result; a more elegant form combines the lead salt with acetic acid and acetate of morphia. Dr. Lawson speaks well of a solution of acetate, 10 to 20 gr. in ½ oz. each of plain water and lime-water, for all kinds of *burns, wounds*, and *ulcers* (Lancet, ii., 1875). Mr. Freer, from much practical experience, recommends the carbonate of lead with linseed oil (white paint) in preference to the acetate, or indeed to any other application; it has the advantage over nitrate of silver of being painless, and it often relieves very quickly (Lancet, i., 1859). It is good not only in erysipelas, but in burns, carbuncles, eczemas, etc., since it excludes air and exerts a sedative effect—it may be applied with a feather, and a fresh coat put on every two hours or so, and left to peel off in a few days. A more elegant mode of using the carbonate is with glycerine, 1 dr. to 4 gr. of the powder, and 1 oz. of cerate; this is useful for erythema.

Conjunctivitis.—Warm lead lotions, with or without opium, are very serviceable in ordinary catarrhal cases, but it is

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important they should not be ordered if the corneal surface be abraded, or else an opaque white deposit may be left.

Eczema.—In cases of moist discharging eczema, lead lotions are often soothing and sometimes curative; a combination of the liquor plumbi 1 oz., with glycerine ½ oz., and cherry-laurel water 3½ oz., is very good for subacute cases, but may require dilution. Mr. B. Squire gives the preference to a *glycerole* of subacetate of lead, in the preparation of which glycerine is used instead of the water of the officinal liquor (Med. Times, i., 1876): 1 part of this in 4 of glycerine or of vaseline is a useful strength. Equal parts of the liquor plumbi and glycerine have given me as good results in chronic eczematous conditions, and more especially in mentagra. In some cases, the iodide of lead ointment will be found useful.

Wounds.—Mr. Hutchinson has strongly recommended the continuous use of lead lotions in operative surgery. Within about six hours of any serious amputation he applies over and near the part, compresses soaked in a lotion containing ½ oz. of liquor plumbi, and 1½ oz. of spirit of wine, in a pint of water, and kept constantly moistened every half-hour for several days and nights. This constant attention is essential to success, and is the only troublesome part of the treatment, which seems to prevent inflammation, to have some antiseptic power, and certainly to promote union by first intention,—no poisonous symptoms have been observed from it (Lancet, i., 1875). Zeissl advocated a similar dressing for bubo, after observing the unfavourable results of routine treatment by incision, etc., as carried out in certain German hospitals; he kept the surface constantly covered with linen soaked in solution of basic acetate of lead, and found that inflammation and suppuration were much controlled, and convalescence hastened (Med. Times, i., 1872, p. 521).

Onychia.—Powdered nitrate of lead I have found a remarkably good resource in cases of onychia, and it has quickly benefited when ordinary treatment had failed (Marsh, MacCormac, Scott, etc., B. M. J., i., 1874). Professor Perizzi was the first to draw attention to this.

Sore Nipples.—Dr. Fordyce Barker speaks highly of the nitrate of lead (10 to 15 gr. in the ounce of glycerine) as an application to sore nipples (Med. Times, ii., 1873, p. 503).

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Enlarged Glands, etc.—The ointment of lead iodide is often useful in chronic adenitis and splenic enlargements, also in chronic synovitis.

Leucorrhœa, etc.—In cases of purulent and muco-purulent discharge from the vagina, the urethra, the ear, etc., lead lotion is very useful, and may be used at any stage, since, if sufficiently dilute, it does not irritate, like alum and some other astringents. If, however, improvement is not obtained from weak dilutions, the full strength should be tried, and zinc sulphate may be added in the proportion of 1 or 2 gr. to the ounce of lead lotion.

THERAPEUTICAL ACTION.—*Internal.*—**Hæmorrhage.**—The acetate of lead has decided power over many forms of internal hæmorrhage, and is still in frequent use, though not so much so as formerly. Dr. Elliotson often prescribed it in 2 to 3-gr. doses; Dr. Stokes says "nothing can be more striking than its power to arrest the discharge in chronic *bronchial* hæmorrhage," and I have more than once verified this. Dr. C. J. B. Williams recommends 3 gr. with opium every hour or half-hour in cases of *hæmoptysis*, taking care to give a daily dose of purgative salts (Lancet, i., 1862). In the hæmorrhage of *enteric fever*, acetate of lead is often valuable.

In an obstinate case of *hæmaturia* (renal), after failure of tannin, iron, and other remedies, grain doses of lead acetate, with ½ gr. of opium, given every six hours, soon arrested all bleeding; a blue line appeared on the gums within a week of this treatment (Gull, Lancet, i., 1866). In *uterine hæmorrhage*, acetate of lead with opium is often suitable. Dr. Dewees used it largely in plethoric menorrhagia and in hæmorrhage occurring during pregnancy.

Dr. Workman has written to advocate a novel prescription, which theory would scarcely seem to justify, though the practice is said to be advantageous; he gives the acetate in ½ to 1 dr. doses without any opium; this causes diarrhœa, but no other bad symptoms, and produces, he says, the best results in hæmoptysis and also in uterine hæmorrhage, and causes contraction of the uterus (Med. Record, 1878).

Phthisis—Chronic Bronchitis.—At one time, acetate of

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lead was thought valuable in consumption, and it may relieve some of the symptoms, such as profuse sweating, expectoration, and diarrhœa, but the cases said to be cured by it were probably of chronic bronchitis, with excessive secretion. M. Beau has, however, written comparatively lately to advocate again the advantages of lead treatment in phthisis, recommending the carbonate in gradually increasing doses (Lancet, ii., 1861). He founded his practice upon some cases of phthisis which recovered after working in lead-factories, and concludes that a moderate degree of lead-poisoning is antagonistic to the malady—but such an opinion is not generally accepted. I need scarcely say that other physicians condemn the use of lead salts in phthisis "as worse than useless" (Med. Times, i., 1860, p. 435). The truth probably lies between the two extremes, but a decided objection to any continued use of the drug is its impairment of appetite.

Pneumonia.—Under the use of lead acetate, a good proportion of success in the treatment of pneumonia has been reported by Brandes, Strohl, Leudet, and others (B. M. J., i., 1863).

Aneurism.—Since the observations of Dupuytren, who reported three cases of aortic aneurism relieved by lead acetate (together with small bleedings and rest), this remedy has been tried by many physicians. Dr. Owen Rees reported a case of acute popliteal aneurism (Lancet, i., 1865), with thin walls, and no coagula in the sac, which did not improve under pressure, and was thought incurable without operation; on October 29th, 3 gr. of acetate with opium were ordered thrice daily, the diet was not restricted, nor rest enforced: on November 1st, there was a slight blue line on the gums: on November 5th, the dose was increased to 5 gr., and this was continued for twenty-six days, when the remedy was stopped on account of colic: aneurismal pulsation had ceased. On December 31st the man was at work, and on January 17th reported cured. This rather striking instance I have not found supported by the results of others, though Dr. A. Clark reports a case of thoracic aneurism in which 2 gr. of acetate with opium were given thrice daily for two months, and the patient got better; he was kept constantly at rest (Med. Times, ii., 1867, p. 566). Stillé remarks that the sacculated form of aneurism can only be cured

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by coagulation of blood in the sac, and in so far as acetate of lead promotes this, it assists a cure, but in the fusiform aneurism, with symmetrical distension, no mere astringent can exert a salutary power. Bellingham objects to the use of lead in any case, and Mr. T. Holmes, who has known aneurism develop during the course of a lead colic, asserts that the acetate is of no real value in the treatment of the malady (Lancet, i., 1872). Dr. Bristowe points out that it may help to quiet the circulation, but cannot really coagulate blood within the vessels, otherwise its administration would lead to danger from thrombosis or embolism. From a general review of the evidence at present before us, I should conclude that although individual cases of apparent benefit may be cited, as a rule very little can be expected in aneurism from the use of lead.

Diarrhœa—Dysentery.—Stillé has collected a large amount of evidence, American and foreign, in favour of lead acetate as a remedy in many forms of these disorders. Graves and others have recommended it in cholera. It certainly exerts a powerfully astringent effect, but should not be used without due regard to the elimination of irritating material by previous purgation if necessary. In some cases of obstinate diarrhœa amongst the ill-fed children of the poor, I have found it exceedingly useful.

PREPARATIONS AND DOSE.—*Plumbi acetas:* dose, ½ to 3 gr. or more. *Pilula plumbi cum opio:* dose, 4 to 8 gr. (1 gr. of opium in 8 gr. of the pill mass). *Plumbi iodidum:* dose, ¼ to 1 gr. *Suppositoria plumbi composita:* (1 gr. of opium and 3 gr. of acetate in each). The following are for external use only:—*Plumbi oxidum; emplastrum plumbi* (diachylon); *emplastrum plumbi iodidi; unguentum plumbi acetatis; liquor plumbi subacetatis* (Goulard extract); *liquor plumbi subacetatis dilutus* (Goulard water); *unguentum plumbi subacetatis comp.* (contains camphor, wax, and oil,—better made with vaseline); *plumbi carbonas; unguentum plumbi carbonatis; plumbi nitras.*

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POTASSIUM—KALIUM, K, = 39.

This metal has not been found native, but its various compounds are very widely diffused. The nitrate occurs in various soils, and the chloride in mines, the tartrate in the juice of the grape and other fruit, and carbonates and chlorides are found in the ashes of all woods and plants; chloride of potassium abounds especially in the seeds of leguminosæ (Berthier). From vegetables this salt passes into the animal organism, and hence the milk and the urine of herbivora contain much more of it than the same secretions of carnivora: the blood-globules and the contractile substance of muscle contain a comparatively large proportion of it.

CHARACTERS.—The metal itself is soft and silvery-white, so light (sp. gr. ·865) that it floats on water, and with such affinity for oxygen that it abstracts that gas from the water, thus setting free hydrogen which ignites and burns with a violet purple flame, characteristic of the presence of potassium. Some liquid devoid of oxygen—like benzine—is therefore required for keeping the metal; if exposed to the air it rapidly oxidizes to potash.

COMPOUNDS OF POTASH.

Potassii iodidum (*v.* p. 76). *Potassii bromidum* (*v.* p. 125).

LIQUOR POTASSÆ—SOLUTION OF POTASH, KHO, = 56.

PREPARATION.—By adding slaked lime to a boiling solution of about twice its weight of carbonate of potash; carbonate of lime subsides, and the clear solution of potash is transferred by means of a syphon to a bottle, which should be of green glass.

$$K_2CO_3 + CaH_2O_2 = 2KHO + CaCO_3.$$

(The solution would corrode wool or other organic filters, and would dissolve lead in white glass.)

CHARACTERS AND TESTS.—A colourless liquid of acrid taste, and strongly alkaline reaction; sp. gr. 1·058; contains

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nearly 6 per cent. of caustic potash, or 27 gr. in the fl. oz.; it feels soapy when rubbed between the fingers, on account of its solvent action on the cuticle; it corrodes animal and vegetable substances, and forms soluble soaps with oily and fatty bodies. It is liable to contain carbonate of potash, lime, sulphates, chlorides, and alumina. The best general test for potash salts in solution is perchloride of platinum, which precipitates a yellow double chloride.

POTASSA CAUSTICA—CAUSTIC POTASH—HYDRATE OF POTASH—POTASSIC HYDRATE, KHO, = 56.

PREPARATION.—By rapidly evaporating the *liquor* to dryness in a clean silver or iron vessel, then fusing and pouring into suitable moulds.

CHARACTERS AND TESTS.—Occurs in hard fibrous pencils, which should be white, but are often bluish in colour; of peculiar nauseous odour, and acrid taste. It has a strong affinity for water and carbonic acid, and readily deliquesces if exposed to the air: is soluble also in alcohol. Heat is evolved during its solution in water.

POTASSÆ CARBONAS—CARBONATE OF POTASH, K_2CO_3, = 138.

PREPARATION.—From the ashes of plants which consist of a soluble carbonate, and insoluble salts of lime, silica, etc. The carbonate is dissolved out by frequent washing with water, which is then evaporated, and the residue fused to a brown stony mass—the crude potashes of commerce (black potash). This is purified by calcination in a furnace, the dull white residue being termed "pearl-ash," and this again is further purified by solution in a small quantity of water, filtering, and evaporating to dryness. The carbonate may also be obtained by heating to redness the bicarbonate.

CHARACTERS AND TESTS.—Occurs in small white opaque crystalline grains, having strong alkaline taste and reaction; it is distinguished from the bicarbonate and from sodium salts by its great affinity for water, for on exposure it soon deliquesces into a thick liquid.

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POTASSÆ BICARBONAS—BICARBONATE OF POTASH,
$KHCO_3$, = 100.

PREPARATION.—By passing carbonic acid gas through a strong solution of carbonate of potash; the stream of gas should be disengaged slowly but continuously for a week: crystals of bicarbonate are gradually deposited.

$$K_2CO_3 + H_2O + CO_2 = 2KHCO_3.$$

CHARACTERS AND TESTS.—These crystals are large, transparent, colourless, rhombic prisms, which are not deliquescent and not caustic; they are soluble in four parts of cold, and less than their own weight of boiling water, insoluble in alcohol: nearly neutral to test paper.

POTASSÆ ACETAS—ACETATE OF POTASH,
$KC_2H_3O_2$, = 98.

PREPARATION.—By neutralizing acetic acid with carbonate of potash; the acetic takes the place of carbonic acid, which is liberated with effervescence.

$$K_2CO_3 + 2HC_2H_3O_2 = 2KC_2H_3O_2 + H_2O + CO_2.$$

The liquid is evaporated, and the salt dried, melted, and crystallized.

CHARACTERS AND TESTS.—Occurs in white, smooth, glistening, and generally long pieces, which are soft, fibrous in texture, and unctuous to the touch: neutral in reaction, very deliquescent, and soluble in alcohol, as well as in water.

POTASSÆ CITRAS—CITRATE OF POTASH, $K_3C_6H_5O_7$, = 306.

PREPARATION.—By neutralizing carbonate of potash with citric acid; a reaction similar to the last-mentioned occurs, but this acid being tribasic, requires three equivalents of carbonate for saturation.

$$3K_2CO_3 + 2H_3C_6H_5O_7 = 2K_3C_6H_5O_7 + 3H_2O + 3CO_2.$$

CHARACTERS AND TESTS.—Citrate of potash is a white, granular, crystalline powder, deliquescent, soluble in water.

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insoluble in alcohol. It is charred by hot sulphuric acid, and its solution gives a precipitate with chloride of calcium only when boiled—a test which distinguishes it from tartrate of potash.

POTASSÆ TARTRAS—TARTRATE OF POTASH,
$K_2C_4H_4O_6$, = 226.

PREPARATION.—By boiling the acid tartrate with carbonate of potash and water, when an equivalent of hydrogen in the acid salt is replaced by one of potassium, and carbonic acid given off.

$$2KHC_4H_4O_6 + K_2CO_3 = 2K_2C_4H_4O_6 + H_2O + CO_2.$$

The liquid is then concentrated to crystallization.

CHARACTERS.—Occurs in small granular crystals, deliquescent, soluble, neutral in reaction, and somewhat bitter in taste.

POTASSÆ TARTRAS ACIDA—ACID TARTRATE OF POTASH—CREAM OF TARTAR, $KHC_4H_4O_6$, = 188.

PREPARATION.—Grape-juice contains a large quantity of this salt, which is retained in solution by the saccharine matter. When this latter is converted into alcohol by fermentation, the acid tartrate is gradually deposited inside the wine casks, and is known as "crude tartar," or "argol," and this, when purified by recrystallization, constitutes "cream of tartar," a name originally given to the fine crystals which were "skimmed off" the evaporating liquid.

CHARACTERS AND TESTS.—Occurs as a gritty white powder, or in fragments of cakes. It is distinguished from the neutral tartrate by its very sparing solubility in water, viz., 1 in 180 parts: in spirit it is insoluble, like other tartrates. It chars on exposure to heat, giving off inflammable gas and an odour of burnt sugar.

POTASSÆ SULPHAS—SULPHATE OF POTASH, K_2SO_4, = 174.

PREPARATION.—There is no process directed in the Pharmacopœia, but the salt may be prepared from the residue left

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in the manufacture of nitric acid, this residue being an impure acid sulphate, which is converted into the neutral salt by treatment with lime, and afterwards with carbonate of potash and sulphuric acid.

CHARACTERS AND TESTS.—A very hard crystalline salt, sparingly soluble in cold water; decrepitates on heating: has a bitter, rather nauseous taste.

POTASSA SULPHURATA—SULPHURATED POTASH (HEPAR SULPHURIS).

PREPARATION.—By fusing together carbonate of potassium and sublimed sulphur.

CHARACTERS AND TESTS.—From its liver-colour, when fresh, it was formely called "liver of sulphur," but it rapidly absorbs oxygen from the air and becomes green, and ultimately dull white, sulphate of potash being formed. It evolves sulphuretted hydrogen on the addition of any acid.

POTASSÆ NITRAS—NITRATE OF POTASH—NITRE—SALTPETRE, KNO_3, = 101.

PREPARATION.—Nitrates occur naturally in many waters, soils, and plants, but are mainly obtained either from certain soils in India by solution in water, or from artificial "nitre beds," *i.e.*, heaps of manure and vegetable refuse, wood ashes and calcareous earth, which are exposed to the action of air and sun. The nitrogen of the organic matter is slowly oxidized into nitric acid, which combines with the bases present (potash, etc.), and the nitrates so formed are removed by washing.

CHARACTERS AND TESTS.—Occurs in white crystalline fragments, or in striated, long, six-sided prisms, which are transparent. It is soluble in water, and has a cooling taste; at a red heat it deflagrates. When fused and cast into round moulds, it is known as "sal prunelle"; abroad, these are often coloured purple (like a plum: *prunelle*—a *sloe*).

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POTASSÆ CHLORAS—CHLORATE OF POTASH, $KClO_3$, = 122·5.

PREPARATION.—By passing chlorine gas over a mixture of potash carbonate and excess of slaked lime; chlorinated lime and chlorinated potash are first formed, and the latter is then converted into chlorate of potash on boiling; but the reaction may be simply expressed thus—

$$6Cl_2 + K_2CO_3 + 6CaH_2O_2 = 2KClO_3 + CaCO_3 + 5CaCl_2 + 6H_2O$$

CHARACTERS AND TESTS.—Chlorate of potash occurs in pearly-white, hard, crystalline plates, which are slightly soluble in water, and have a cooling taste. Rubbed with sulphur, or phosphorus, or tannic acid, or catechu, etc., the salt explodes; treated with sulphuric acid, it becomes red, and gives off vapours of chlorine peroxide.

POTASSÆ PERMANGANAS—PERMANGANATE OF POTASH, $KMnO_4$, = 158.

PREPARATION.—The principal steps of the process are—(1) to prepare manganate of potassium (K_2MnO_4); (2) to convert this into permanganate ($KMnO_4$) by boiling. Black oxide of manganese, caustic potash, and potassic chlorate are fused together, and a dark green mass of manganate of potash obtained.

$$3MnO_2 + 6KHO + KClO_3 = 3K_2MnO_4 + KCl + 3H_2O.$$

This manganate, when boiled, filtered, and acidified with sulphuric acid, yields a purple solution of the permanganate.

$$3K_2MnO_4 + 2H_2O = 2KMnO_4 + 4KHO + MnO_2.$$

The green manganate, when turning into the purple permanganate, undergoes several changes of colour, and hence has received the name, "mineral chameleon:" finally, the solution is evaporated, and the crystals purified.

CHARACTERS AND TESTS.—Occurs in dark purple acicular crystals, one of which will impart its colour to a large quantity of water. It yields up most of its oxygen (five-eighths) very readily; and if only a little spirit be boiled with its solu-

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tion, it changes to yellowish brown, on account of its reduction to the state of peroxide. A similar brown stain is left on the hands when washed in it, on account of its oxidation from contact with the organic substance. In distilled water, the purple colour may remain two years without change. (Manganese stains are removed by oxalic acid—"salts of lemon.")

POTASSÆ BICHROMAS—BICHROMATE OF POTASH,
$K_2Cr_2O_7$, = 295.

PREPARATION. — By roasting chrome iron-ore with a mixture of carbonate of potash and chalk; yellow chromate of potash is formed, and yields the red bichromate when treated with sulphuric acid.

CHARACTERS AND TESTS.—Occurs in large, red, transparent, four-sided tables, soluble in ten times their weight of water. The solution readily gives up part of its oxygen, and when acidified with sulphuric acid, turns green from reduction of the chromic acid, and formation of green sulphate of chromium.

ABSORPTION AND ELIMINATION.—*Liquor potassæ*, taken on an empty stomach, is quickly absorbed; it then combines, probably, with carbonic acid in the blood, and is eliminated by the kidneys, mainly in combination with sulphuric acid (Parkes, Med.-Chir. Rev., 1853). When taken with food, or in very small doses at any time, it forms with the gastric acid a chloride, and as such is absorbed; its elimination under these conditions is not recognized so readily.

The *carbonates*, when taken in small doses, are absorbed as chlorides; of large doses, the greater part passes out by the kidneys unchanged: a single large dose (2 dr.) is eliminated more quickly than the same amount given in divided doses (Thompson, Med.-Chir. Rev., ii., 1864). The *acetate* and *citrate* are reduced in the system to carbonate, and eliminated as such; the *tartrate* is commonly unchanged. The *chloride*, *chlorate*, and *nitrate* are absorbed very rapidly, and have been detected in the urine, the saliva, etc., within five minutes after being taken.

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Much interest attaches to the chemical changes which the *chlorate* undergoes in the system; it was believed to become a chloride, parting with its oxygen to the blood and tissues (Fourcroy),—the proportion even of oxygen furnished was calculated (Garnett). Gubler and some other modern observers also think it possible that a partial reduction of the salt may occur within the body, but it is difficult to reconcile this with the chemical fact of its being found *unchanged* in the urine passed after its administration (Wöhlér, 1824), as also in the saliva, milk, tears, bronchial mucus, etc. (Isambert). Rabuteau, taking himself small doses, also found the drug *unchanged* in the secretions, and of one large dose of 5 grammes, recovered 4·873 grammes from the urine within thirty-six hours (Gaz. Méd. de Paris, 1868). Hence it seems improbable that the chlorate should decompose and give up oxygen at the temperature of the body, and yet there is some clinical evidence of its improving oxygenation in whatever mode this may be effected (*r.* pp. 24, 746).

When *nitrate* of potash has been taken in large doses (270 gr. in twenty-four hours), the greater part has been found unchanged in the urine—the rest probably passing as sulphate by the intestines (Taylor, Guy's Reports, 1863); that a certain amount of potash salt passes off in this manner has been shown by Kramer (Annales d'Hygiène, i., 1843).

PHYSIOLOGICAL ACTION.—**Oxidation and Nutrition.**—How far alkalies, as such, contribute to oxidation, has long been a question of interest, and it is one of great practical importance. Organic substances, such as bile and hæmatin, when exposed to air outside the body, certainly oxidize more quickly when in contact with potash (Chevreul, 1825): olein, again, is not acted on by ozone alone, but if potash be added, oxidation sets in at once. We know, also, that albumen, dissolved in water, changes but slowly, whilst the addition of alkali induces immediate oxidation, and in the ordinary test for diabetic sugar, potash deprives of oxygen even a metallic oxide.

Physiological chemists did not fail to trace a similar action within the body. Lehmann and Mialhe taught that alkalies were powerful promoters of systemic oxidation, and augmented

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the excretion of urea and carbonic acid. Liebig fully adopted the same view, teaching that they promoted the combustion of "respiratory foods," and pointing out that if organic acids (gallic, citric, etc.) were taken alone, they passed off almost wholly unchanged, but if in combination with alkalies, *e.g.*, as citrate of potash, the acid was "burnt off" in the system, and the alkali passed as a carbonate. The experiments of Frerichs illustrated the same point; he gave urate of potash to rabbits, and yet found no uric acid in the urine, for it became changed into oxalic acid and urea, the excretion of the latter being much increased.

Bence Jones concluded that alkalies, though they could not themselves give up oxygen, decidedly assisted oxidation of organic substances within the body by promoting the formation of acids (Lectures, and Lancet, i., 1867, p. 202), and Parkes found, in a series of analyses, that the organic material and sulphuric acid excreted in the urine were markedly increased under the use of liquor potassæ, which acted, he considered, by increasing the oxidation of sulphur and protein tissues; for this effect it had to be given at least eight hours after food (Med.-Chir. Rev., 1853). Similar results did not follow the use of acetate or nitrate of potash in Parkes's experiments, but Dr. Golding Bird reported a considerable increase of urea and other urinary solids in the case of a dog submitted to the action of 3 dr. of the acetate (On Urinary Deposits). Dr. Reginald Thompson proved by several series of observations, that the amount of phosphoric acid in urine was increased by the administration of carbonate of potash (Med.-Chir. Rev., ii., 1864).

Besides the cases reported by Dr. Parkes, we have clinical evidence from Dr. Austin Flint of much increase in the urinary solids of a number of patients taking nitrate of potash, and Dr. Basham, observing specially cases of lithic acid diathesis, not only found the urea increased under the use of potash, but oxalic acid appeared as uric acid lessened, and oxalic acid and urea are recognized products of the oxidation of uric acid.

We might almost conclude from the preceding statements that the question as to alkalies increasing oxidation was answered in the affirmative, and yet practical experience shows that some qualifying statement is required, for do we not see marked

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asthenia, pallor, and anæmia produced in many persons by full doses of alkali, and in all persons by their continued use? (so that Trousseau speaks of their doing more harm than the abuse of iodine or mercury); and moreover, is not temperature reduced by salts of potash, so that they are used as anti-pyretics? whereas, if they increased oxidation, the results should be opposite to these. (Dr. Ridge argues that although some amount of alkali promotes oxidation, the "secondary effect" is to retard it—Med. Times, ii., 1871.) To advance knowledge in this direction, Rabuteau has recently recorded the results obtained on himself, on Constant (of Smyrna), and on a third person (a woman). Each took 5 to 6 grammes of bicarbonate of soda or potash for five to ten days. The full dose of bicarbonate of potash produced a slight diuretic effect, but 5 grammes none at all; urea was markedly and progressively *diminished*, and depression and anæmia were induced: analogous results were obtained by Ritter, of Nancy; 5 grammes of chlorate equally *diminished* urea (Fouilhoux, Thèse, Paris, 1874), and 10-gramme doses of nitrate acted in a similar manner (Jovitzu).

The explanation of such contradictory results turns largely upon the question of dosage, as with many other medicines. Large quantities, like those last referred to, will pass out unchanged and quickly, and in their passage so far deteriorate the blood-condition and impair the function of the alimentary tract as to induce asthenia and diminish nutrition; hence evidently Dr. Parkes's supposition that increasing the dose of potash will proportionately increase oxidation cannot be sustained. Small doses, on the other hand, not only help to saponify fatty food, but aid its oxidation, and that of carbonaceous material generally, improve the digestion, and raise the temperature.

Rabuteau himself confirms these statements, and explains these effects of small doses by their change into *chloride* in the stomach, and their acting as chlorides rather than as alkalies; under the influence of 5-gramme doses of chloride of potassium he found the excretion of urea increased by 20 per cent.

That potash salts are essential for the development of the animal tissues is shown by the fact that food which in itself is not sufficiently nutritious, such as over-stewed meat, recovers

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its properties on the addition of these salts and of a little sodium chloride (Binz); the absence of potash salts seems to be at least one cause of scurvy (Garrod). If, on the other hand, we give meat broth, which is very rich in potash salts, without adding any other nutrient, tissue-change becomes so accelerated that animals thus fed die earlier than others kept without food.

Experiments with plants show also how necessary potassium is for cell-nutrition; if it be excluded from their soil and water no growth takes place, for without its presence in the chlorophyll granules no starch is produced.

Souligoux, in a recent treatise, emphasizes the necessity of a due amount of alkali for carrying on all the vital processes, and brings evidence to show that a large part of its good effect lies in its favouring proper *electrical* reactions and currents within the organism (Etude sur les Alcalins, 1878, Paris).

Circulatory System.—A certain amount of potash salt is essential, as we have seen, for the proper constitution and action of the corpuscles, and the chloride seems to be the best suited for this purpose (Rabuteau); but the prolonged use of the remedy in any combination has an unfavourable effect. Loffler has reported the results in five of his students who took doses of from 1 to 5 dr. of alkaline carbonates for several days, and then allowed blood to be taken from a vein. It was found to be like "cherry juice" in colour and density, the red corpuscles were paler, and the white ones more numerous than normal; there was excess of water and of fatty material, and the clot was less firm and elastic than it ought to be (Schmidt's Jahrb., 1848). A curious illustration of the diminished coagulating power of the blood under the influence of nitrate of potash is furnished by Dr. Stevens, who had occasion to bleed a man who had lately taken an ounce of that salt, and was surprised to find the venous blood red, and not at all coagulable (Lancet, ii., 1862, quoted by Dr. Basham). In animals, after injection of nitrate, the result is similar (Rabuteau).

Martin Solon, having analysed blood drawn from the vein of a robust man suffering from acute rheumatism, and treated by nitre, found the fibrine diminished, though the inflammatory process was still at its height; ten days afterwards, when the remedy was no longer being taken, the blood-clot was dense

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and buffed (Bull. de Thérap., 1843). That the drug cannot, however, be depended upon for antagonising the effects of disease is shown by the fact of fibrinous deposits having been found on the heart-valves in patients dying during its free administration (Med. Times, i., 1863).

Both this salt and the chlorate have the power of rendering venous blood bright red, and much stress was laid upon this change by the early advocates of the direct oxygenation theory (Stevens, O'Shaughnessy, Lancet, ii., 1831), but Isambert, after making fresh experiments, asserts that their statements on this point are incorrect (Gaz. Méd., 1874), and although the change does occur, it varies with physical conditions, and is dependent rather on altered osmosis than on difference in oxygenation.

Small doses of the potassium salts (excepting the permanganate) cause a fall in the pulse-rate, but a rise in the arterial pressure, probably through the vaso-motor nerves; this effect is usually only temporary (Aubert, Dehn). *Full* doses lower both pulse-rate and blood-pressure. The lowered pressure may, or may not, be followed by a rise according to the dose employed. Parkes found a full dose of *liquor potassæ* render the pulse small and slow, but a copious secretion of urine explained this effect. Under the *nitrate* the pulse-frequency came down in a few days from 76 to 64 (Rabuteau, p. 229), and the *chlorate*, according to Socquet, of Lyons, has a similar sedative action. Some observers report a *quickened* circulation, especially after venous injection of chlorate (Gubler); Jacobi speaks of this salt congesting the kidney (Med. Times, i., 1876), and Osborn of its congesting the brain (Lancet, ii., 1859); but such effects must be exceptional. The observations of Black (1839), and of Bouchardat (1844), and the experiments of Podocæpow (Virchow's Archiv, Bd. xxxiii., p. 505), of Guttman, Aubert, Dehn, and others agree in assigning to potash salts a distinctively *depressing* effect on the heart-action. Their injection in frogs quickly lessens the force of the blood-current, and finally arrests the heart in diastole: 10 gr. of chloride injected into the jugular vein of the smaller animals cause instant cardiac death, and since the heart-muscle in such cases is found insensitive to electricity (Traube), and since previous section of the vagi has no influence on the result, we conclude that the cardiac

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arrest is due to a direct paralysis of the muscular substance. This paralysis is commonly preceded by increased activity, but finally it becomes complete, so that the heart-muscle ceases to react to any ordinary stimulus. If, however, the potash chloride be introduced *gradually* into the system through the stomach, then cardiac contractility is not entirely destroyed by it.

The bitartrate of potash has some power of arresting hæmorrhage, especially from the kidney (Ramskill and others, Ranking, i., 1867); it possibly lessens congestion by diuresis or purgation. Albuminuria has occurred under the influence of nitrate.

Nervo-Muscular System.—Large doses of potassium salts lower the reflex irritability of certain parts of the spinal cord (Binz), but many observers consider this to be only secondary to depression of the circulation. The fall of temperature induced is attributed to the same cause. In warm-blooded animals motor power is weakened, probably from a direct alteration in the *chemical* constitution of muscular elements, for *electrical* reaction remains. (On the other hand, Ramskill finds baths of *sulphuret* of potassium to be the most effective stimulant to muscular action during such diseases as wasting palsy—Med. Times, ii., 1860.) In healthy men a sense of weight and fatigue is often felt in the limbs after absorption of the more easily diffusible salts, as the nitrate, oxalate, chloride, iodide, or bromide; local anesthesia of various parts of the body has been described as a result of drachm doses of the bicarbonate (B. M. J., ii., 1876). There seems, however, to be some idiosyncrasy with regard to such effects, and although full doses usually depress the nerve-functions, Dr. Prout refers to pronounced nerve-excitement, and even convulsion in some cases, as connected with an excess of alkali, and the chlorate of potash is said to have caused headache and cerebral congestion (*v.* p. 733) Isambert considered it a nervine sedative, but "this action was not evident in healthy persons" (Med. Times, ii., 1856). Rabuteau finds the "perchlorate" to produce giddiness and other symptoms like those of quinine. Liquor potassæ has been used to quiet the spasms of tetanus (Lancet, i., 1861).

Dr. Thompson traces the nerve-depression commonly caused by alkalies to an increased excretion of phosphoric acid under their use (*v.* p. 730).

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Glandular System—Mucous Membranes.—Dilute alkaline solutions taken into the stomach *before* meals augment the secretion of gastric juice (Blondlot, C. Bernard), for if digestion is to continue, fresh secretion must occur to compensate for what is neutralized; also the chlorides that are formed augment the secretion (Rabuteau). "They favour the outward osmosis of those constituents of the blood from which the acid of the stomach is elaborated" (Bartholow). But alkalies given in too large or too concentrated a dose arrest the secretion, and if given soon *after* a meal prevent even a normal amount of acidity. Dr. Ringer formulates a general proposition thus:—"Alkalies applied to the orifices of glands with acid secretions increase their secreting power, while alkalies applied in a corresponding way to glands with alkaline secretion lessen or check this secretion;" and I think that, as a general rule, and with due regard to the strength of solution, this may be held true.

The increased secretion of saliva caused by direct application of alkalies is thick, whitish, and cloudy; it is not large in amount, and there is some doubt as to whether it is true secretion or (as Kühne thinks) the result of a rapid degeneration of the gland. A similar fluid results from irritation of the sympathetic nerves of the submaxillary gland, and hence the alkali has been thought to act through the sympathetic. The chlorate of potash sometimes acts so as to produce a degree of salivation.

Under the influence of alkalies taken internally, the bile and pancreatic juice are increased in amount, and rendered more fluid. The sulphate of potash given internally has special power in this direction (Rutherford), more than magnesia. The bronchial secretions are also increased and fluidified by alkalies, and the movements of ciliated epithelium are rendered more active by them.

Secretion from the intestinal glands is augmented, especially by full doses of the potash salts of mineral acids: 2 or 3 dr., *e.g.*, of the sulphate cause watery purging; larger quantities sometimes irritate much: ½-oz. doses have been used in France as abortifacient with serious effects (Mowbray), and 2 oz. have caused death (Taylor).

The nitrate in small doses is absorbed and produces some constipation, but in full doses and well-diluted causes diarrhœa

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(Martin Solon, 1843). Orfila reported violent irritation of the mucous membrane from its use, and an ounce has caused death with irritant symptoms and depression, though this is exceptional. The experiments of Rognetta indicated only a moderate degree of congestion—no inflammation; and ounce doses, when well diluted, have been given medicinally without serious result.

The chlorate may also irritate mucous membranes, and in large doses has sometimes, though rarely, caused death through this effect, *e.g.*, in a patient with phthisis, who took 300 gr. daily for four days, and in the case of Dr. Fountain, who unfortunately took an ounce in order to prove his conviction of its innocent character (Stillé).

The bichromate in small doses increases all the secretions, in large doses acts as an irritant poison, and induces suppression of urine.

The urine is often markedly increased in quantity by liquor potassæ (Parkes), by the bicarbonate and the chlorate, but still more by the bitartrate, nitrate, acetate, and citrate; the increase is not always decided, unless the urine is rendered alkaline. There is a marked difference in different compounds as to their production of alkalinity: thus, a single dose of 40 gr. of acetate alkalinized the urine in a few hours, and then was not all changed, but of the bicarbonate several drachm doses were required. In febrile diseases, salines, such as nitrate of potash, may cause at first marked lessening of excretion, afterwards increase (Parkes, Med. Times, i., 1855). In cases of irritant poisoning by the potash salts of the mineral acids, suppression of urine has occurred, probably reflex in character.

SYNERGISTS AND ANTAGONISTS.—The other alkalies are allied in chemical action to the salts of potash, and acids are the chemical antagonists. Gubler suggests that soda is antagonistic to potash (dynamically) in its action on the blood and on respiratory combustion, because potash only, not soda, is contained normally in corpuscles, and under certain conditions may be replaced by the latter when given in full doses.

THERAPEUTICAL ACTION.—*External.*—Caustic potash has been used in surgery for the same purpose as other powerful

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caustics, and has the special characteristics of being deliquescent and of dissolving and deeply penetrating the tissues; parts near the seat of its application should therefore be protected by plaster, or by oil, and the cauterized place should be sponged with dilute vinegar to prevent undue action. The slough caused by it is leathery, soft, dark-coloured, and moist, not dry like that of nitrate of silver; it separates after a variable time, according to its thickness.

Issues—Abscess—Bubo, etc.—For the purpose of making an issue, or of opening a large collection of matter, such as a chronic or "cold" abscess, caustic potash was formerly often, and for the latter purpose is still occasionally, used. Macnamara has found better results from it than from the knife in opening bubo (Ranking, i., 1872), and others recommend it in carbuncle. It causes pain but no hæmorrhage, and makes a good free opening for the escape of the slough.

Caries—Necrosis, etc.—Caustic potash and concentrated solutions of the carbonate have been recommended in these conditions, but sulphuric acid is to be preferred (Med. Times, ii., 1860, Lancet, i., 1870). In ununited fracture, potash has been used to vivify the ends of the bones.

Varix—Nævus.—It is said to have the power of obliterating the trunk of a varicose vein (Bonnet), and also of destroying superficial nævi (Wardrop); but the application is painful, and is apt to leave a very evident cicatrix. Powdered nitrate of potash kept in contact with the nævus, is said to give a better result in slight cases.

In **Hospital Gangrene**, the part may be first dressed with the solid caustic, and afterwards with a lotion containing it in gradually diminishing proportion—400 cases are said to have been treated successfully by this means (Restelle, Brit. and For. Rev., Oct., 1850). Lotions of permanganate and of chlorate are also valuable.

Strumous Ulceration.—In strumous ulceration of superficial and indolent character, with livid undermined edges, and affecting extensive surfaces on the trunk or extremities, caustic potash lightly applied to the margin often stimulates to satisfactory healing.

Lupus.—For cases of ulcerative lupus in which the strumous

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character is most marked, caustic potash is sometimes a good agent; we do not apply it generally for lupus about the face, because of the unsightly cicatrix which is apt to follow its use; but in Vienna it is in frequent request, and is found to succeed when other remedies have failed.

Epithelioma—The disadvantage of the deliquescent character of potash may be obviated, and its efficacy rather increased by combination with caustic lime, two parts of the latter to one of the former constituting "Vienna paste;" it should be kept dry, and moistened only with a little spirit as required. Epithelioma affecting the lip has been sometimes cured by successive applications of this caustic, but it is painful and tedious. The *chlorate*, given internally and applied locally, has also been said to arrest and cure epithelioma, and certain Paris surgeons especially have reported well of the local use of concentrated solutions. I have observed several cases treated in this manner, but without substantial benefit.

Uterine Ulceration.—Pure caustic potash has been applied to ulcerations and hyperplasiæ of the cervix uteri, and although disastrous results, such as contraction and cicatrix have occasionally followed, it may be of decided service, in skilled hands, not only for irregular ulcerative conditions, but also in chronic cervicitis with induration (areolar hyperplasia); in such cases it may be applied about every ten days for several times, and free injections of vinegar and water should be used afterwards. Dr. Henry Bennet recommended it or the lime compound "as a last resource," and the Vienna paste is sometimes serviceable. French surgeons use the same remedy, with an additional quantity of lime, carefully prepared in lead or iron tubes (caustic of Filhos, of Robiquet).

Primary Syphilitic Ulcers, Warts, etc., have been sometimes destroyed by caustic potash. The bichromate is very useful for this purpose.

Urethral Stricture has been treated by the application of caustic potash to the affected part, and in some cases of cartilaginous hardness, and of unusual irritability, it apparently proved useful—with due precautions—but the majority of modern surgeons rightly, I think, object to any direct caustic application in such cases.

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Leucorrhœa—Gonorrhœa.—In the former affection, when the discharge is profuse and strongly alkaline, and either transparent or white, coming probably from the glands of the cervix uteri, a weak alkaline injection (1 dr. of bicarbonate to the pint) thoroughly applied, will often relieve; but injections of chlorate (2 dr. to the pint) act better, especially if the discharge be at all purulent (Amer. Med.-Chir. Rev., Nov., 1858). The permanganate should be used if there be a disagreeable odour.

In gonorrhœa, injections of the permanganate (1 to 5 gr. to the ounce) have been highly praised, especially in the second stage (Med. Times, ii., 1862). In many cases they certainly act well, but care should be taken to begin with a weak solution, for I have known pain and irritation produced by such injections. Besides the local applications of potash salts, the scalding and burning pain in micturition may be much relieved by the bicarbonate, or perhaps better by the acetate and nitrate, given internally with mucilage, etc., it is said even that the attack may be cured by them (Lancet, ii., 1850, p. 507). In chronic cystitis with fœtid urine, injections containing chlorate (4 gr. to 1 oz.) are recommended by Braxton Hicks.

In-growing Nail, etc.—This troublesome affection may be well treated by means of dilute liquor potassæ (2 dr. to the ounce of water) constantly applied on lint, between the nail and the soft tissues, so as to thin the nail and render it flexible, when it can be rubbed or pared away (Norton, Lancet, i., 1869).

Unhealthy Wounds.—Several compounds of potash have valuable disinfectant and also alterative properties, especially the permanganate (Condy's fluid), and the chlorate, and when used in the form of lotion prove of the greatest service in removing fœtor and promoting healthy action. For the *bites of rabid animals* its penetrating and alkaline powers render liquor potassæ valuable; in *snake-bite* especially it should be applied locally as well as given internally; it fluidifies the blood and promotes bleeding from the bitten part (*v.* p. 751).

Stomatitis—Diphtheria.—In aphthous conditions and unhealthy ulcerations about the gums, palate, or tonsils, gargles containing the chlorate or permanganate are very good (*v.* p. 748). In diphtheria, both these salts have proved of great service

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(Ranking, i., 1865). A useful proportion of the permanganate for local application is about 10 gr. to the pint of water.

Eczema.—A weak lotion of bicarbonate of potash (or of soda), 30 to 60 gr. in the pint, will often relieve the early discharging stages of eczema, and a stronger application (caustic potash, 5 to 20 gr. in the ounce) is a useful stimulant to patches in the chronic stage; although painful, it markedly relieves the itching, which is often worse than pain. The German school especially have reduced to a system the application of potash, in the form of their sapo viridis ("schmeier-seife"), which is made by boiling some animal oil with potash and its carbonate; it forms a soft amber-green compound, more elegant than our "soft-soap." Of this a general bath is prepared with 1 dr. to the pint, a second strength (1 dr. to ½ oz. of water) is used for infiltrated subacute patches, and a third (1 dr. to 2 dr. of water) acts as a caustic for very chronic cases; besides these the German codex contains a "spirit of soap," etc. The solution of selected strength should be thoroughly brushed in, and the irritation quickly relieved by a stream of cold water. The use of such remedies is painful, and causes profuse serous secretion from the part; before commencing a course of them, vascular irritation should be subdued by cold water, etc., and afterwards it will be found desirable to use some emollient, such as glycerine or oil, otherwise the skin becomes harsh and dry. There can be no doubt that in some chronic forms, and especially in chronic eczema of the scalp, the soft soap treatment gives remarkably good results (Med. Times, i., 1860).

Sebaceous Disorder—Acne, etc.—In cases of greasy skin and of obstructed follicles, soft soap is a good remedy. In the former it cleanses and tends to lessen secretion; in the latter it dissolves obstruction, but it should be used cautiously if much inflammation be present. Alkaline drops or injections are useful for softening and evacuating hardened cerumen in the meatus.

Scabies—Ringworm.—Preparations of potash (soft soap, etc.) are indirectly useful in parasitic disorders by softening the epidermis and removing secretion, and thus allowing the more direct contact of sulphur or similar remedies, hence the car-

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bonate is a frequent ingredient in pomades for scabies. The sulphocyanide of potassium is a direct parasiticide, and has been commended by Dr. Gee in ringworm (½ oz. in 8 oz. water).

Psoriasis.—The diffused forms of this disease may be much relieved by alkaline baths (potash and soda carbonates together, of each 3 oz. in the bath), and thickly accumulated scales may be removed by frictions with soft soap. Oil of cade may be usefully combined with the same remedy (soft soap, rectified spirit, oil of cade, equal parts). Hebra applies to severe cases a daily friction with soft soap for many days, not using a bath during the course, but keeping the patient in blankets. This is, however, a painful process, on account of the great tension of skin induced whenever strong potash applications are made to the general surface.

Lichen—Urticaria, etc.—Weak solutions of potash salts or liquor potassæ relieve the itching and irritation of these disorders, also of pruritus, and to some extent of pruritus vulvæ. A lotion made by boiling ½ oz. of potassa sulphurata in 1 pint of water, is very useful.

Rheumatism, etc.—The carbonate of potash, dissolved in a bath of warm water, is often useful to relieve pain in the joints, and irritable eruptions in rheumatic and gouty subjects. The sulphuret of potash, on the other hand, furnishes a bath which stimulates especially the muscular system, and has proved useful in plumbism, in locomotor ataxy, and other forms of paralysis; it has the distinctive properties of sulphur. The silicate of potash, or "liquid glass," applied on saturated bandages, makes an excellent splint for fractures (Darby, Med. Times, ii., 1870).

THERAPEUTICAL ACTION. — *Internal.* — **Dyspepsia.**— In cases of irritative dyspepsia, especially when occurring in stout and rheumatic or gouty persons, and marked by red tongue, acid eructations, or pyrosis, with nausea and discomfort after meals, the liquor potassæ or bicarbonate of potash, taken at that time (*after* meals), often gives relief; in gouty cases, and when the urine is loaded, they are to be preferred to soda. In cases of atonic dyspepsia, however, with pale coated tongue and much weight after food, small doses of alkali are best given *before*

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a meal, and if continued for some time should be combined with a bitter infusion. In cases of "biliousness," with yellowish complexion and conjunctivæ, headache, nausea, etc., and even in actual catarrhal jaundice, salts of potash are good adjuvants (Golding Bird, Bartholow). Dr. Todd recommended the sulphuret (10 gr.) when the "mucous follicles were implicated."

In *vomiting* connected with the condition just described, or with other functional or even organic gastric disorder, or occurring at the commencement of inflammatory fevers, the bicarbonate of potash is advantageously given in effervescence with citric acid.

Acid Poisoning.—In cases of poisoning by the mineral acids, bicarbonate of potash may be employed not only to neutralize the acid, but as an emetic, by giving first a large dose of the alkali, and a suitable quantity of citric acid some minutes afterwards. The amount of carbonic acid evolved distends the stomach so as to assist discharge of its contents.

Lithiasis—Calculus.—In cases of excessive secretion of uric acid, potash salts are useful by assisting oxidation of the acid to some extent, and also by furnishing a base with which the acid is readily eliminated in a soluble form; they should be considered, however, rather palliative than curative, and attention should be equally directed to diet and hygiene during their use.

The continued administration of potash had, at one time, much reputation in the treatment of uric acid calculus, and Dr. William Roberts (Manchester) has shown, by careful experiments, that benefit may be expected from it under certain conditions. It is specially adapted for renal calculi which cannot be reached in any other way, and for small vesical calculi consisting either of uric acid or of cystine. The acetate and citrate of potash are the best to use, and in order to secure a sufficient and continuous alkalescence of the urine, 30 gr. for children, 40 gr. for adults, of either salt must be taken at intervals of about three hours. This quantity will give to the urine an alkalinity equal to 3 or 4 gr. of carbonate in the pint, which may be kept up for several weeks without injury to the general health, but the urine must be frequently examined, and if it become ammoniacal the treatment should be omitted.

As an illustration of its occasional value may be cited the

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case of the Rev. V. Harcourt, who, at the age of eighty, continued it for three months, rendering the urine alkaline to the extent of 20 to 25 gr. per pint, with relief to many painful symptoms, and with much advantage (Med. Times, ii., 1869). For phosphatic calculi, potash is, of course, unsuitable.

Skin-Disease.—Several forms of cutaneous disease are connected with a gouty or rheumatic diathesis, especially forms of eczema and psoriasis; in such cases the urine is often scanty and loaded, and then alkaline diuretics are of service. Mr. Easton has shown the advantages of the acetate (Edin. Month. Journ., May, 1850); the liquor potassæ is also given successfully.

Acute Rheumatism.—Up to comparatively recent times, alkaline treatment, by potash especially, was accepted as the best for rheumatic fever. Amongst its principal supporters, Dr. Fuller claimed that it would prevent cardiac lesions, for such lesions did not occur in any of a large number of cases thoroughly brought under the influence of alkalies (Lancet, ii., 1862). He argued that these remedies not simply neutralized abnormal acidity, but restored normal alkaline conditions, maintained fibrine soluble, exerted a sedative influence on the circulation, and favoured complete metamorphosis of tissue; he pointed out, also, that for a fair trial correct diagnosis was essential, and that true rheumatism should not be confounded with the gonorrhœal affection, with rheumatic gout, pyæmia, etc., and such a mistake would account for failures; he approved of a compound prescription—thus, ℞. Liq. ammon acetat. ℥ij., sodæ bicarb. ʒiss., potas. acetat. ʒss., with citric acid in effervescence.

Sir Thomas Watson recommended liquor potassæ, and Dr. Parkes made use of it (Med.-Chir. Rev., 1864), but it is not really so suitable as the neutral salts. Todd preferred the bicarbonate or acetate in ½-dr. doses every three hours (Ranking, i., 1869). Dickinson has written in favour of the same method, and Golding Bird in favour of the acetate specially, whilst Dr. Basham was a constant advocate of the nitrate (Lancet, 1848, and ii., 1862); he used large doses, from 1 to 3 oz. daily, in 4 pints of barley water. Dr. Wade found the best results from a combination of these two salts in moderate doses, 15 to 20 gr. of acetate with 8 to 10 of nitrate, and other observers have corroborated his experience (Fleischman, Lancet, i., 1869, etc.).

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On the other hand, Dr. Sutton concluded that none of these remedies could influence the course of rheumatic fever, or prevent heart-complications, though they might allay pain (Med.-Chir. Trans., vol. lii.). Dr. Ringer, from his own observation, came to a similar conclusion, whilst Dr. Ridge and others have argued that they are injurious (Med. Times, ii., 1871). No doubt the continued use of large doses may induce depressing anæmia, and consequent tedious convalescence, and now that the salicylates and other remedies are better known, we are not so dependent on alkaline medication; it must, however, be held a valuable resource in cases marked by high degree of acidity and loaded urine, and its judicious use may greatly relieve. In my own practice I commonly combine iodide of potassium with bicarbonate in effervescence.

Ague.—Nitrate of potash has been given successfully in ague—10 gr. every two or three hours (in brandy); it increases the secretions, notably the perspiration and urine, and is said to be as sure a specific as quinine, leaving even less tendency to relapse! (Ranking, i., 1869).

Specific Fevers.—Alkalies, especially in effervescence, greatly relieve the thirst and other distressing symptoms in various fevers, and they promote elimination by the skin and the kidneys, etc. The chlorate has been recommended in *enteric* fever by Chomel, but has not been largely given; in *scarlet* fever, I, with others, have found it of much advantage (Watson, Copland): even in *yellow* fever, in the later stages, it is said to do good (Med. Times, i., 1875).

Diphtheria.—Chlorate of potash in full doses, either alone or combined with iodide, has seemed very useful to many observers (Squire, Hillier, Perrin, Henoch, Vogel). I quite agree with them; I have for twenty years used it more or less with advantage. In America, it is commonly given with chloride of ammonium. Recently Dr. Ciattaglia (Rome) has recorded his very successful results with doses of 10 to 15 grammes daily; but in addition he thoroughly applied to the affected part a wash of chloral—1 dr. in 5 of glycerine (Lancet, i., 1876).

The permanganate of potash has also proved useful in diphtheria, as well internally as locally (Copland, Lancet, i., 1863, p. 151, and Ranking, i., 1865, p. 55). I can add my testimony

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to its value, though it is right to recognize the statements of Dr. H. C. Wood, that he "has never seen the chlorate do a particle of good in such maladies as scarlet fever, diphtheria, etc.," and with regard to the permanganate, "as immediate decomposition of it must occur in the stomach, the absurdity of its internal use needs only to be pointed out" (Elements of Therapeutics, 473—586).

Croup.—Liquor potassæ has been used in croup both locally and internally. Certainly it will dissolve fibrinous membrane outside the body, and to some, but not to a great, extent may be available in the form of spray (½ or 1 dr. to 1 oz. of water). It has been compared to mercury in its constitutional effect of fluidifying secretion and of promoting absorption, but it acts too slowly to be depended upon for so acute a malady as croup. Iodide of potassium is more effective, and the acetate of potash seems to have sometimes acted well. The bichromate I have occasionally used locally and internally, with excellent effect, in true membranous croup.

Pneumonia.—The nitrate of potash is said to be valuable in the early stages (Dub. Quart. Journ., July, 1873), but as Dr. Jones, who commends it, used also antimony and ipecacuanha, we cannot verify its precise effects.

Bronchitis—Catarrh.—When expectoration is scanty, viscid, and brought up with difficulty, either in early or later stages of bronchitis, alkalies often relieve, and may be taken with other expectorants. The liquor potassæ in doses of 10 to 15 min. is one of the most suitable forms: the nitrate is also useful, and is commonly combined with Dover's powder, or with antimony and tinct. camph. co. (Graves, Clin. Lect.). Laborde has found the chlorate very serviceable, both in acute and chronic catarrhal bronchitis: it modifies and dilutes the expectoration, which gradually lessens in amount; the respiratory sounds become normal, the cough is relieved, and appetite improved (Bulletin, Oct., 1864). In ordinary catarrh I have found the chlorate a very good remedy; it is recommended also by Dr. Sedgwick (B. M. J., i., 1873).

Asthma.—The inhalation of fumes of "nitre paper" is often valuable in this malady, and I, with others, strongly recommend it, especially for spasmodic asthma, though it is often available

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also in the bronchitic form, if congestion be not very acute. The paper may be made with thick blotting-paper, saturating it in a hot solution of nitrate of potash (4 oz. to ½ pint), then drying and dividing it as required. In some cases a little of this is sufficient, and a less strength of solution is desirable, but in others relief is not obtained till the room is filled with the vapour (Times, i., 1874, p. 64.) Dr. Murrell has recently reported much relief from thick strong papers covered with crystals of nitrate or chlorate; when lighted they give out "dense volumes of smoke" (B. M. J., i., 1881). Sometimes, however, especially if there be extensive or active congestion, such treatment proves irritant, and its first use therefore requires watching.

Pertussis.—The carbonate of potash was at one time in good repute in the treatment of whooping-cough, but we cannot expect more from it than the thinning of tracheal and bronchial secretion, and a slight sedative effect on the mucous membrane. The acetate has been especially recommended (Practitioner, vol. ii.), also the sulphuret; the latter is given in doses of 1 gr. per year up to four years, after that age in the proportion of ½ gr. per year. It is important that its solution should be freshly prepared: it is rather nauseous, and acts sometimes as an emetic, but if continued for four or five days will usually do good (Ranking, i., 1869, p. 65).

Phthisis.—The value of chlorate of potash in phthisis has been much disputed: by some it has been esteemed a specific, and though it really cannot be called so, it has the power of relieving at least some of the symptoms. Dr. Fountain introduced it with the hypothesis that it gave up oxygen to the blood (*v.* Physiological Action), and seems to have found benefit from the salt, not only in consumption, but in various disorders with impeded respiration (Med. Times, ii., 1859, Amer. Journ., 1860).[1] Dr. Harkin records that in the first or second stages of phthisis doses of 5 to 20 gr. improved colour and strength, and diminished cough and diarrhœa (Dub. Quart., Nov., 1861). Dr. Symonds considered it of service in promoting the healing of

[1] Mr. Whymper has recently reported its good effects in relieving headache, and other symptoms induced by highly rarefied air, at an altitude, *e.g.*, of 16,500 feet on Chimborazo; it was recommended to him by Dr. Marcet.

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vomicæ (B. M. J., i., 1868), and Spender, pointing out that full doses may readily be given, because of its great solubility in boiling water, "regrets that its value in phthisis is not better known" (Brit. and For. Rev., i., 1872). On the other hand, Dr. Flint's observations satisfied him of benefit from the drug in only one out of fourteen cases, mostly advanced (Amer. Quart. Rev. and Med. Times, ii., 1861). Dr. Cotton could trace no definite effects to it, though it seemed to improve the vigour of cachectic individuals generally. I have myself known the carbonate as well as the chlorate relieve pleuritic stitches, diminish profuse purulent expectoration, and check copious perspiration.

Chronic Hoarseness—Aphonia.—In these conditions, whether connected with chronic chest-disorder (not laryngeal phthisis) or with over-exertion in talking or singing, I have frequently prescribed from 5 to 15 min. of liquor potassæ with advantage; in fact this simple remedy, given every four hours for a few days, has quickly relieved and sometimes quite cured the symptoms.

Struma—Asthenia.—Many observers agree in attributing benefit to the chlorate in strumous asthenic conditions, more or less allied to phthisis. Dr. Harkin used it in all forms of scrofulous glandular ulcerations. Mr. Weeden Cooke praised it in "scrofula," and in the generally impaired condition which follows exanthematous disease (Lancet, ii., 1869). It has also acted well in improving the general state during pregnancy, and even in preventing the recurrence of abortion (Edin. Med. Journ., 1866). The early reputation of potash in struma was founded mainly on the success of Brandish with liquor potassæ, but good air and hygiene were essential elements in his cures. This medicine will sometimes induce the absorption of glandular tumours, but cannot be considered curative of the constitutional taint; it is now practically replaced by iodide of iron and cod-liver oil.

Suppuration—Ulceration of Mouth.—In cases of suppuration, such as carbuncle or continued eruption of boils, or discharging wounded surfaces, also in sloughing or gangrene, the chlorate and permanganate have been found useful internally as well as locally, but it is especially in ulceration about the mouth, the gums, and the fauces that chlorate of

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potash is most valuable. Mr. Hutchinson has recorded many cases occurring in unhealthy children, and very obstinate until this remedy was given in full doses of from 10 to 30 gr. (Med. Times, ii., 1856). Mr. Hunt introduced it as a specific in ulcerative and gangrenous stomatitis (Med.-Chir. Trans., xxvi.), and I consider it a most valuable remedy when used internally and locally in these affections. In relaxed sore throat and catarrhal pharyngitis the chlorate is often serviceable, and is commonly prescribed in the form of lozenge.

In *mercurial stomatitis* it has proved useful (Herpin, Hutchinson, etc.), and Ricord administered it with mercury to obviate injurious effects from the latter. Sir T. Watson quotes a formula containing the chlorate 10 gr., with an equal quantity of sulphur, as "almost a specific," but my own experience is rather that of Bartholow and some other observers, viz., that the chlorate does not give, in mercurial maladies, the same good results as in ordinary stomatitis.

Diarrhœa.—The chlorate of potash has been recommended in dysentery, and even in inflammatory diarrhœa (Amisy, Lancet, ii., 1872, p. 300). Marotti considers the acetate valuable in gastro-intestinal disorder connected with chronic catarrhal conditions and increased secretion of mucus in the alimentary canal, and marked by coated tongue and anorexia (Practitioner, vol. ii.), but I think we have more dependable remedies. I should rather avoid it in acute conditions of this kind, but in the form connected with advanced stages of chronic nerve-disorder and cachexia, or "vaso-paralytic" diarrhœa, its use is more indicated. The chlorate is an ingredient in the "saline treatment" of cholera.

Constipation.—The sulphate of potash acts as a mild aperient, and is suitable for cases of dyspepsia with deficient biliary secretion, or hæmorrhoids; it is often combined with rhubarb, especially for children (West, Hillier). Dr. Dickinson recommends it in doses of 10 to 20 gr. as a good laxative in albuminuria (Lancet, i., 1876, p. 628); in larger doses it is apt to cause griping. The acid tartrate is also used as an aperient, especially in cases of hæmorrhoids and of dropsy, since it produces a copious watery secretion into the intestinal canal, but it should be combined with some more active agent to secure efficient expulsive effect; thus it is ordered with sul-

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phur in the confectio sulphuris, and with jalap in the pulvis jalapæ compositus.

Purpura—Scorbutus—Hæmorrhage.—In purpura simplex, 10-gr. doses of nitrate of potash have been sometimes useful, and even in hæmorrhagic purpura the same remedy in large doses (10 to 60 gr.) has been recommended (Carlyon). The advantage of potash salts in true scurvy is not clear, but for the special ulceration of the gums, the chlorate is certainly good (Lancet, ii., 1860, etc.). Both the nitrate and the tartrate are of service in the treatment of capillary hæmorrhage; the former has been used, especially in hæmoptysis accompanied with febrile excitement (Gibbon), and the latter in hæmorrhage from the kidney, bladder, and rectum. Half-drachm doses of the acid tartrate quickly arrested a hæmorrhage connected with a malignant growth of the bladder, and 2 dr. is an efficient dose for relieving the loss of blood from piles (Ramskill, B. M. J., i., 1867).

Cirrhosis of the Liver.—The acid tartrate of potash is said to be "of singular value in alcoholic cirrhosis" (Gull, Lancet, i., 1866, p. 6).

Obesity.—There are on record some remarkable cases in which the use of potash salts, and especially of liquor potassæ, has reduced the amount of fat deposited, but these remedies are by no means always effective for this purpose, nor should they be employed without real necessity and due care, for fear of inducing a spansemic condition. In a case of *local* excessive deposit of fat round the neck of a girl, which was very unsightly, and for which no available treatment could be at first suggested, the use of 15 to 20 min. doses of liquor potassæ ter die, led to marked improvement, and so quickly as to be clearly traceable to the remedy (Lancet, i., 1873). In some other cases of fatty tumour, liquor potassæ has also been given with success as regards diminution of the growth.

Diabetes.—The use of alkalies in this malady was at one time largely adopted, in the hope that their property of assisting oxidation would be of direct service, but this hope has been in the main disappointed. The permanganate especially was recommended by Sampson (Lancet, i., 1853), and also by Ramskill (Med. Times, ii., 1867), but has not proved reliable (Bence

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Jones, Basham, and others): it seems, however, to have the power of relieving the intense thirst of the malady. The compound alkaline waters of Vichy, Carlsbad, etc., really ameliorate many cases (*v.* p. 208). The nitrate, chlorate, and tartrate are also serviceable in polydipsia, and are given dissolved in water or lemonade: the citrate in effervescence may give much temporary relief.

Albuminuria—Dropsy.—The use of alkaline diuretics is advantageous in the early stages of this malady, the citrate of potash or the acetate being the most suitable; they are presumed to act directly on the kidney, washing away *débris* and epithelium, which obstruct the tubules. In later stages, when dropsy is present, and indeed in all forms of dropsy, 20-gr. doses of the acetate, or half that quantity of nitrate, given in conjunction with digitalis, squill, or other vegetable diuretics, often secure a copious secretion from the kidneys.

Cyanosis.—Although, as before remarked, the theory of oxidation of the blood by means of chlorate of potash cannot be scientifically maintained, yet I have certainly seen benefit from that salt in cases of congenital cyanosis: the colour and the temperature have both improved under its continued use. Dr. Balthazar Foster has recorded two remarkable cases, in which he obtained similar results (Clin. Medicine). Mr. Harding found it (the chlorate) useful "in cases with lividity, and coldness of lips and extremities, and symptoms of obstructed circulation" (Med. Times, ii., 1861), and Dr. Fountain and others have had the same experience.

Tetanus—Chorea.—The power of potash to alter and diminish the contractility of muscular tissue, furnishes some theoretical ground for an old method of treatment of tetanus by means of potash-baths, and the internal administration of the carbonate, "the method of Stütz" (Husemann): practically, this is not often employed, but some cases in which it was successful may be found recorded (Lancet, i., 1861). In chorea, also, baths of the same kind have been found beneficial by G. Sée and by Hillier. The internal administration of potash may be desirable, for a time, at least, in cases with rheumatic taint, but must not be pushed to the production of spanæmia.

Blood-poisoning—Pyæmia.—The influence of potash upon

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oxidation, and upon the blood-condition, have led to its employment in cases of absorption of poisonous material.

Savory has found it of distinct value, not in acute, but in chronic pyæmia (Lancet, i., 1867, p. 202), and Sir James Paget records the disappearance of a chronic pyæmic abscess under the use of liquor potassæ (Barth. Hosp. Rep., vol. i.).

Snake-bite.—Dr. Shortt, the eminent ophiologist of Madras, has recorded indisputable evidence of its value when quickly and largely used after the bite of venomous snakes. He gives it in several ways, in order to saturate the blood as soon as possible: thus internally, 20 min. are ordered with 1 oz. of brandy and ½ oz. of water; 1 dr. is injected into the veins every hour, and general and local bathing with a strong solution (4 oz. to the bath) is constantly practised (Med. Times, ii., 1873).[1]

Syphilis.—By those who decry or discourage the use of mercury in syphilis, the chlorate of potash is much depended upon as a substitute, especially in infantile forms of the disorder (Drysdale, Dub. Press, Dec., 1862). I believe that it may contribute to the healing of ulceration in this as in other cachexiæ, but I cannot attribute to it special anti-syphilitic power. More has been claimed for the bichromate, and it seems to have proved sometimes useful, especially in ulcerated throat (syphilitic) and in iritis; a pill containing $\frac{1}{10}$ to $\frac{1}{6}$ gr., with opium, is the best way of giving it, for its solution is apt to nauseate. In large doses it is an irritant poison, and its action as a remedy has not been well proved nor extensively tried. I have myself been greatly disappointed with its effects in some obstinate cases of syphilitic disease.

PREPARATIONS AND DOSE.—*Potassii bromidum* (*v.* p. 153). *Potassii iodidum: Linimentum potassii iodidi cum sapone* (*v.* p. 121). *Liquor potassæ:* dose, 10 to 60 min., freely diluted. *Potassa caustica. Potassæ carbonas:* dose, 10 to 20 gr., freely diluted. *Potassæ bicarbonas:* dose, 10 to 30 gr. as an antacid, etc.; in acute rheumatism, 30 to 60 gr. every four hours, freely diluted with water. *Liquor potassæ effervescens:* "potash water," dose, 4 to 8 oz. (contains ½ gr. in the ounce). *Potassæ acetas:*

[1] M. de Lacerda has recently reported that intravenous injection of a 1 per cent. solution of permanganate, soon after an injection of snake venom, has proved antidotal in dogs (Oct. 1881).

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dose, 10 to 60 gr. as a diuretic; 120 gr. and upwards as a purgative. *Potassæ citras:* dose, 20 to 60 gr. *Potassæ tartras:* dose, 20 to 60 gr. as a diuretic and alterative; 120 to 200 gr. as a purgative. *Potassæ tartras acida:* dose, 20 to 60 gr. as a refrigerant or diuretic; 120 to 300 gr. as a hydragogue purgative (contained in confect. sulphuris). *Potassæ sulphas:* dose, 20 to 120 gr. as a purgative; smaller doses as an alterative. *Potassæ nitras:* dose, 5 to 20 gr. as a refrigerant and diuretic; 20 to 30 gr. as a vascular sedative. *Potassæ chloras:* dose, 5 to 20 gr. *Trochisci potassæ chloratis:* 5 gr. in each lozenge. *Potassæ permanganas:* dose, ½ to 4 gr. *Liquor potassæ permanganatis* (contains 4 gr. to the ounce—for external use, 1 fl. dr. to 5 or 10 oz. of water). *Potassa sulphurata:* dose, 3 to 6 gr. in pill (often used in much smaller doses in pill or in water,—$\frac{1}{10}$ gr., or even less for children). *Unguentum potassæ sulphuratæ:* (should be recently prepared). *Sapo mollis.*

SODIUM—NATRIUM, Na, = 23.

This metal does not occur native, but in various combinations is found extensively throughout all the kingdoms of nature; the chloride especially is abundant in the animal organism, also in sea-water, in many mineral springs and marine plants, as well as in mineral formations. The nitrate of soda occurs as an efflorescence on the soil in some countries.

CHARACTERS AND TESTS.—Sodium, the metallic base of soda and its compounds, is of waxy consistence, and silver-white colour. It has a great affinity for oxygen, and when placed upon water floats like potassium, producing effervescence from escape of hydrogen, and combining with the oxygen of the water to form soda: the sp. gr. is 0·972. Sodium is the only metal of which the ordinary salts are all soluble in water, and therefore do not furnish precipitation tests: we have, however, an excellent reaction in the flame-test, *i.e.*, the communication of an intensely yellow colour to a clear flame; so delicate is this test, and so universally diffused are the compounds of sodium, that it is difficult to obtain a flame perfectly free from all traces of them (Smith).

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COMPOUNDS OF SODA.

SODA CAUSTICA—CAUSTIC SODA—HYDRATE OF SODA, NaHO, = 40.

PREPARATION.—By evaporating liquor sodæ to dryness in a silver, or clean iron vessel; the process is conducted as rapidly as possible to prevent absorption of carbonic acid, and platinum, glass, or porcelain vessels are not admissible because the alkali would act upon them. A pure hydrate is now prepared by decomposing water with metallic sodium.

CHARACTERS.—Occurs in whitish cakes or pieces which are highly alkaline and corrosive: it is not so deliquescent as potash.

LIQUOR SODÆ—SOLUTION OF SODA.

PREPARATION.—By adding slaked lime to hot solution of carbonate of sodium, $Na_2CO_3 + CaH_2O_2 = CaCO_3 + 2NaHO$.

CHARACTERS.—A colourless liquid, of intensely caustic taste, containing nearly 19 gr. of caustic soda to the ounce.

SODÆ CARBONAS—CARBONATE OF SODA, $Na_2CO_3 10H_2O$, = 286.

PREPARATION.—This is carried out on a large scale for commercial purposes, and is not described in the Pharmacopœia. The combustion of sea plants formerly furnished us with crude soda-ash, or "barilla," from which the carbonate was prepared, but it is now generally obtained from common salt (chloride of sodium) either by Leblanc's process of treatment with sulphuric acid, to form a sulphate known as "salt-cake," which is strongly heated in a furnace with chalk and charcoal, and afterwards the carbonate is crystallized out; or by "the ammonia process," in which the bicarbonate of ammonia precipitates from the salt solution a bicarbonate of soda, and from this the carbonic acid is driven off by heat, to be utilized in other steps of the manufacture.

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CHARACTERS.—Occurs in large rhombic crystals, colourless and transparent when fresh, but readily effloresing on exposure to air; of nauseous alkaline taste, very soluble in water, not at all in alcohol: they contain 63 per cent. of water of crystallization, which they lose at a sufficient heat. Twenty grains of carbonate of soda neutralize 9·7 gr. of citric, and 10·5 of tartaric acid.

Sodæ Carbonas exsiccata, or dried carbonate of soda, being the same salt deprived of water and powdered, is introduced as a separate preparation for convenience in dispensing: 1 gr. = about 2½ gr. of the crystallized salt.

SODÆ BICARBONAS—BICARBONATE OF SODA, $NaHCO_3$, = 84.

PREPARATION.—By passing a stream of carbonic acid gas into a mixture containing two parts of the crystallized and three parts of the dried carbonate, until the gas ceases to be absorbed. (If the ordinary carbonate only were used, the mass would become too moist and the crystals too large): by a special arrangement of vessels, the delivery of the carbonic acid is made continuous, as in the case of bicarbonate of potash.

CHARACTERS.—Occurs in small snow-white grains or scales, or in opaque white powder, slightly alkaline, and somewhat caustic to the taste, permanent in the air, and soluble in water. Good commercial bicarbonate commonly contains 2 or 3 per cent. of carbonate. Twenty grains of the former salt neutralize 16·7 gr. of citric and 17·8 of tartaric acid.

Sodæ Arsenias (*v.* p. 418).

SODÆ SULPHAS—SULPHATE OF SODA—GLAUBER'S SALT, $Na_2SO_4 10H_2O$, = 322.

PREPARATION.—In the process for making hydrochloric acid, an acid sulphate of soda is formed by the action of sulphuric acid on common salt, and if this *acid* sulphate be neutralized with carbonate of soda, the *neutral* sulphate may be crystallized out.

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CHARACTERS.—Occurs in transparent colourless six-sided prisms, which are deeply channelled; they are efflorescent in the air, and have a saline bitter taste and neutral reaction.

SODÆ ACETAS—ACETATE OF SODA, $NaC_2H_3O_23H_2O$, = 136.

PREPARATION, etc.—By neutralizing carbonate of soda with acetic acid: occurs in long striated prisms, which slowly effloresce, and have a sharp, bitter taste.

SODÆ HYPOSULPHIS—HYPOSULPHITE OF SODA (SODIC THIOSULPHATE), $Na_2H_2S_2O_44H_2O$ (*not officinal*).

PREPARATION, etc.—By warming a solution of the sulphite with powdered sulphur: occurs in large colourless oblique prisms, which are very soluble in water, not in alcohol.

SODÆ NITRAS—NITRATE OF SODA, $Na\,NO_3$, = 85.

PREPARATION, etc.—This salt is found native in Peru and Chili, and is purified by crystallization from water. It occurs in the form of obtuse rhomboids, resembling cubes, deliquescent, and very soluble.

SODÆ PHOSPHAS—PHOSPHATE OF SODA, $Na_2HPO_412H_2O$, = 358.

PREPARATION.—Obtained from bone-ash, which is mainly phosphate of lime, by rather a complex process, of which the essential steps are two, viz.: (1) The bone-ash is digested with sulphuric acid, when an acid phosphate is formed and remains in solution, and an insoluble sulphate precipitates. (2) The filtered solution containing the acid phosphate of lime, is then treated with carbonate of soda to slight alkalinity, when phosphate of soda is formed, filtered, and re-crystallized.

CHARACTERS.—Occurs in large, transparent, rhombic prisms, which quickly effloresce in the air; they are faintly alkaline, very soluble in water, and have a mild saline taste.

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SODÆ HYPOPHOSPHIS—HYPOPHOSPHITE OF SODA, $NaPH_2O_2$, = 88.

PREPARATION.—By adding carbonate of soda to solution of hypophosphite of lime, so long as a precipitate (carbonate of lime) is formed; this is filtered off, and the solution evaporated cautiously.

CHARACTERS.—A white, crystalline, bitter salt, deliquescent, and very soluble in water and spirit. It readily decomposes, so that explosions occur with it on mixture, for instance, with chlorate of potash, and friction; and when heated to redness it ignites, and gives off phosphuretted hydrogen.

SODÆ BIBORAS—BORAX, $Na_2B_4O_7 10H_2O$, = 382.

PREPARATION.—Found native in a crude form in Thibet, India, California, etc.; also prepared by neutralizing boracic acid with carbonate of soda.

CHARACTERS.—Occurs in flattened semi-transparent prisms, of slightly alkaline reaction and saline taste, soluble in water, and efflorescing in the air. Its solubility is increased by glycerine and by cream of tartar, and from its solutions boracic acid is precipitated by any mineral acid: it gives a green colour to flame. When heated it dissolves in its water of crystallization, and at red heat forms a transparent glass much used as a flux for mineral substances in blow-pipe operations.

LIQUOR SODÆ CHLORATÆ—SOLUTION OF CHLORINATED SODA.

PREPARATION.—By passing washed chlorine gas through a solution of carbonate of soda, till a sp. gr. of 1·06 is reached. The resulting solution contains hypochlorite of soda, with some chloride and bicarbonate of the same.

CHARACTERS.—A colourless alkaline liquid, with the odour of chlorine, and a pungent taste; sp. gr. 1·103; it bleaches vegetable colours, effervesces with acids, and readily evolves chlorine.

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SODII CHLORIDUM—CHLORIDE OF SODIUM—COMMON SALT,
NaCl, = 58·5.

Is found native in "rock-salt" and saline waters.

CHARACTERS.—Occurs in transparent cubes or small white grains, soluble in water, and if pure, permanent in air: deliquescent, if containing chloride of calcium or magnesium.

SODA TARTARATA—TARTARATED SODA—TARTRATE OF SODA AND POTASH—ROCHELLE SALT,
$NaKC_4H_4O_64H_2O$, = 282.

PREPARATION.—By adding cream of tartar to a hot strong solution of carbonate of soda, so long as effervescence continues, then filtering and crystallizing.

CHARACTERS.—Occurs in large, colourless, rhombic prisms, or halves of prisms, which have been compared to tombstones: they are neutral in reaction, soluble in water, and of saline rather bitter taste.

SODÆ CITRO-TARTRAS EFFERVESCENS—EFFERVESCENT CITRO-TARTRATE OF SODA.

PREPARATION, etc.—By mixing bicarbonate of soda with citric and tartaric acids, at considerable heat (200° F.); with constant stirring, this salt is obtained as a granular powder, which effervesces on contact with water.

ABSORPTION AND ELIMINATION.—The salts of soda, like those of potash, are highly diffusible and readily absorbed. Small doses become changed in the stomach into chloride, but large quantities undergo this change only in part, the rest being absorbed unchanged; from the rectum also, soda salts are absorbed without chemical decomposition. In the blood they circulate as albuminates, carbonates, phosphates, etc., and are eliminated mainly by the urine:—the carbonates, nitrates, and other salts of *mineral* acids in their natural state, but citrates and other salts of *vegetable* acids pass out as carbonates.

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The time that elapses between absorption and some elimination is not precisely known, but is short, for the nitrate and an excess of chloride have been found in saliva and urine within a few minutes after the taking of those salts; also, a very large quantity (60 grammes) of nitrate has been taken in divided doses during a day without injury, whilst half the amount in *one* dose has proved poisonous.

The chloride taken into, or formed in the stomach, is said to decompose into hydrochloric acid and soda, the former passing into the blood to combine again there with soda (bicarbonate), whilst the latter is eliminated, not only by the kidneys, but also by the salivary glands, the liver, the pancreas, etc. (Bidder and Schmidt). The chloride is never completely eliminated from the system even if it be excluded from the diet: on the other hand, if an excessive quantity be taken, most of it is rapidly got rid of: thus, Lehmann, analyzing his blood before and during the action of a salt-dose or salted-diet, found the proportion of salt in the blood to be very similar, the excess being passed out by the kidneys almost as soon as taken (cf. p. 767).

Chloride of sodium in the air, or in finely-divided spray, is absorbed from the pulmonary mucous membrane even more quickly than from the stomach. It does not seem to be absorbed through the unbroken skin, or at least whatever passes, *e.g.*, during a salt-bath, into the epidermis or corium, passes out again in the same bath (Clemens). Soda salts, like alkalies generally, are eliminated to a slight extent by the mucous membranes, especially by those of the respiratory tract, the secretion of which they tend to increase and make thinner: they exercise a remarkable stimulant effect upon the vibratile movements of ciliated epithelium, which they revivify after apparent extinction (Virchow).

PHYSIOLOGICAL ACTION—*External.*—The *hydrate* of soda exerts a local caustic effect, consequent upon its great affinity for water and its power of dissolving nitrogenous tissues. The *carbonate*, applied in solution, dissolves sebaceous and fatty secretions, and if concentrated, acts as an irritant. Solutions of *chloride* redden and stimulate the skin, and if applied to a surface denuded of epithelium, excite much smarting and flow of serum:

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redness is then masked by whitish opacity of the albuminous secretion, and the same whitish appearance may be observed on the inner aspect of the buccal mucous membrane after eating much salted food (Gubler). Strong saline baths may cause cutaneous eruptions.

Salt has a local stimulant or irritant effect on nerve-tissue, and for some physiological experiments, C. Bernard considered it more effective than galvanism. If the exposed sciatic nerve of a frog be dipped in salt and water, immediate spasmodic contraction of muscles occurs in the limb: if the tympanic nerve be so treated, saliva is secreted (Med. Times, ii., 1861).

PHYSIOLOGICAL ACTION.—*Internal.*—**Oxidation and Nutrition.**—Under potassium has been summarized evidence as to the action of alkalies on oxidation, and with regard to the carbonates of soda, we may equally conclude that whilst large and continued doses induce anæmia and asthenia, small quantities, given for a moderate time, help to saponify fatty food, to aid its oxidation, and that of carbonaceous material generally, to improve digestion, and to raise temperature. This is especially the case with the chloride of sodium, and indeed Rabuteau teaches that it is by conversion into this salt that the other sodium compounds produce the good effects mentioned. Confirming conclusions already published by Voit (Brit. and For. Rev., ii., 1862), he showed that the chloride increased "vital combustion," for whilst taking an extra daily dose of 10 grammes of salt, his excretion of urea was 20 per cent. more, and his temperature was half a degree higher than when under a dietary from which salt was excluded. Similarly Kaupp found that with taking 1 gramme of salt, the amount of urea excreted was increased 4 centigrammes, the other soluble constituents of the urine being diminished. According to Zabelin, salt favours absorption of phosphates specially, and rather hinders their excretion, which effect would, to some extent, favour nutrition.

Falck found also increased excretion of urea after giving salt to fasting animals (1872), whilst Münch reported, from large doses, continued for a few days, at first diminished excretion and gain in weight: afterwards a contrary effect (Archiv Verein Gemeinshft., Bd. vi.).

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The carbonate, according to the majority of observers, diminishes the excretion of uric acid, and as this acid results from insufficient oxidation, its diminished excretion implies improvement in oxidation. The reported increase of excretion of carbonic acid requires proof, but is rendered probable by the increase which follows injection of lactate of soda into the veins (Husemann). Animals improve under a ration of salt—their coat becomes smoother, their vigour greater, their flesh more healthy, and if, at the same time, their weight is not increased (Boussingault and Dailly, Comptes Rendues, 1847), it is because the vital processes and combustions all go on with greater energy. We have negative evidence to the same effect in the sufferings consequent on deprivation of salt, as in the American War of Independence, and more lately during the siege of Metz, and Barbier records that certain Russian serfs, deprived for a time of salt (from motives of economy), suffered so much (becoming albuminuric and dropsical), that their lords were forced to supply them with it again (Gaz. Méd., 1838). On the other hand, it is curious that the Tlascalans are said to have lived for half a century without salt (Prescott), and certain Aryan tribes never use it (Fick)—it is possible that the atmosphere, as near the coast, may supply to them what is really necessary.

We must repeat that the above-mentioned good effects of ordinary salt, and of alkaline compounds, are obtained only within certain limits of dose—an excess of the former causes not only thirst and disordered digestion, but impaired blood-conditions, and under daily 5-gramme doses of bicarbonate the urea is diminished, and anæmia and prostration induced (Rabuteau): the nitrate and sulphate also diminish urea (Jovitzu and others), lower temperature, and slow the circulation:—it is probably from alteration of the blood that these effects arise. According to Guttman, if the legs of frogs are immersed in strong solutions of salt, unrest and local swelling occur, then muscular contraction, and ultimately cataract is developed (Med. Times, i., 1860).

Digestive System.—What has been stated under potassium as to the influence of alkalies upon digestion and secretion applies equally to the alkaline salts of soda, but the chloride of sodium has a special value, perhaps from its furnishing in part

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the gastric acid; it aids the solution of albuminous substances, and increases the amount of saliva and gastric juice. Bardeleben proved this by observations on dogs with gastric fistula, though, indeed, many other salts, and even mechanical irritants, will provoke a temporary increase in the gastric secretion. Rabuteau found that salted-diet increased also the degree of its acidity, whether from irritation, or from the special properties of the chloride itself; certainly digestion suffers by its absence (Klein and Verson). The good effects are shown by small doses of 15 to 60 gr. Large quantities tend rather to coagulate albumen, whilst very large and concentrated doses cause vomiting, watery purging, and even gastritis:—in China, they are said to be used for suicidal purposes. Injection of much salt into the crural vein of dogs causes ptyalism, intestinal gurgling, and temporary lessening of the spleen (Podocsepow).

Different osmotic currents are determined by the different modes of administration; when either the chloride or sulphate of soda is injected into the blood, or taken in small quantities that can be quickly absorbed, constipation follows, whilst large amounts, given at one time, induce hyper-secretion and consequent purgation.

The action on bile-secretion is not certainly known: Nasse, experimenting with animals, found it lessened, but observations made after the use of alkaline waters show an increase (Grossmann), and this would be in accord with analogy. Rutherford has shown that sulphate of soda has marked cholagogue properties. According to Pavy, the carbonate not only increases the bile, but also the percentage of fat in the liver, and when introduced into the portal system causes the disappearance of hepatine, without formation of sugar (Guy's Reports, 1861, Proc. Roy. Soc., vol. x.-xi., Med. Times, i., 1865): also the saccharine urine which commonly follows certain traumatic lesions of the sympathetic, does not occur if much soda be previously introduced into the blood; these are curious facts, of which we do not at present see the full bearing (cf. p. 770).

Circulatory System.—It is an important difference between potash and soda, that the former is an active cardiac depressant and poison, whilst the latter has no definite effect on the heart-

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muscle or the circulation. Frogs, it is true, die, but only slowly, after the injection of very large quantities (Podocæpow, Guttmann), whilst upwards of 100 gr. of soda carbonate have been introduced into the vein of a dog with but slight and temporary malaise and muscular weakness (Grandeau, Robin's Journ., 1864). Upon man, large doses seem to have but little effect in directly depressing the circulation.

The chloride of sodium, in small or moderate doses, *increases* the number of corpuscles; thus Plouviez had analyses made of his own blood before and after a course of salt, lasting two months, during which he took daily 150 gr. of salt besides his ordinary allowance, and at the end of the time the red globules were augmented 10 per cent. the fibrine was increased, the albumen diminished (Comptes Rendues, 1847, t. xxv.).

Rabuteau states that blood-corpuscles placed under the microscope disintegrate much less rapidly when salt is added than with simple water, and from this and general physiological results concludes that any influence of salt in apparently increasing the number of globules is exerted by *conserving* them, rather than by supplying food for fresh ones, as iron does.

According to Bergeret, *omission* of salt from a dietary leads to pallor, languor, œdema, and a chlorotic condition, the corpuscles are dissolved, and fibrine deposited (Abstract, Ranking, i., 1871; cf. p. 764), but on the other hand, the *continued use* of soda, as of any other alkali, lessens the number of red corpuscles and deteriorates the blood (Loffler, *v.* p. 732).

Whether the excessive use of highly salted food is the main cause of scorbutic conditions, such as occur in sailors and at whale-fisheries, may be considered doubtful; they may arise from the hardships of such life, from deficiency of potash, of vegetables, etc., but it would almost seem as if either great (relative) *excess* or *deficiency* of the element led to equally injurious consequences. Prussac found that when frogs were placed in concentrated salt solutions or had them injected into the lymph sacs, copious "wandering" of red corpuscles took place from uninjured vessels, and also capillary hæmorrhage (cf. p. 760).

External to the body, salt reddens and liquefies blood-clot.

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The change in colour is attributed by Gubler to liberation of carbonic acid and absorption of oxygen by the hæmoglobin. It is permanent, but I do not think it more than a physical change due to altered osmosis; it may be produced by many other saline compounds.

Soda is more abundant in the serum, whilst potash occurs most in the red globules, and excessive doses of the former alkali may alter this normal relationship, and thus interfere with respiratory combustion and with nutrition.

The proportion of sodium chloride in normal blood has been variously estimated at from 3 to 5 per 1,000. It is diminished in various morbid states, such as cholera, diabetes (Nasse), jaundice, chlorosis; in pneumonia, on the contrary, its elimination is checked, and hence an excess remains in the blood (Beale, Lancet, i., 1852, Bergeron, Thèse de Paris, 1866, and others).

Nervous System.—There is some (not cogent) clinical evidence that excess of soda in the blood leads to convulsive action of the nervous system (Laycock, Med. Times, i., 1863, Hunt, Med. Times, 1856); most observers think an excess of little import.

Urinary System.—With regard to the influence of soda salts on diuresis, opinions are divided, partly, perhaps, because of the different doses employed. Usually some increase in the quantity of urine passed is observed in patients taking carbonates, especially in those with acid dyspepsia, but it is not always the same with healthy persons. Münch found, in five subjects, when perspiration or diarrhœa did not occur, *increased excretion of water* as the principal effect of 3 to 6 or 9-gramme doses of carbonate, but Rabuteau and Constant could not verify any increase with 5-gramme doses, given daily. A continued weak alkalescence of the urine may be secured from about 3-gramme doses of bicarbonate of soda, taken thrice daily at meal-times, whilst one daily dose of 5 gr. will give alkalinity only for two or three hours,—even 1 gramme will do this if taken fasting. Much dilution or warmth of the liquid in which the drug is taken promotes the alkalescence of urine, and it lasts longer in weak or elderly persons.

The chloride will produce the same effect, though not so

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quickly as the carbonate, and under its use earthy phosphates replace free acids (Münch).

Glandular System.—Milk is secreted in increased quantity under the influence of salt. This fact, indicated by Saive, but denied by Boussingault, has been confirmed recently (Rabuteau). In Brazil and some other countries there is a popular custom of watering the food of milch cows with salt water to increase their milk.

SYNERGISTS.—The chemical action of the alkaline salts of soda is shared by other alkalies, the physiological action of the chloride of sodium by other chlorides, both as stimulant of hæmatosis and as irritant in large doses; as *digestive* stimulant, other condiments assist its power.

ANTAGONISTS—INCOMPATIBLES.—Acids antagonize the chemical effects of alkaline salts of soda, though the vegetable acids are often added to them to secure liberation of carbonic acid gas and formation of neutral salts. Mucilaginous substances lessen the local irritant effects of excessive doses of chloride, nitrate, etc., and the chloride itself is a suitable antidote for nitrate of silver. Prussic acid and cyanides, perhaps also arsenic and antimony, antagonize the hæmatinic effects of chloride of sodium.

THERAPEUTICAL ACTION.—*External.*—**Strumous Ulceration, etc.**—For destroying unhealthy growths, the edges of strumous ulceration, etc., caustic soda has been sometimes used. It is less deliquescent than potash, but yet is very diffusible, and readily extends its action: it therefore requires the precaution of protecting adjacent parts, and of neutralizing with weak vinegar or oil after application.

Glandular Scrofulosis.—A strong solution of salt locally applied is a good resolvent of enlarged and hard glands: sea-bathing is useful for the same purpose.

Frictions with a pomade containing salt cause a pustular eruption, and have been used over the chest in phthisis (Med. Times, ii., 1859).

Hoarseness—Catarrh.—A piece of borax allowed to dis-

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solve slowly in the mouth sometimes cures these conditions. A spray containing salt (gr. iv.-v. ad ℥j.) is also useful.

A simple mode of stimulating the external surface in some chronic catarrhs and relaxed throat-conditions, is sponging or bathing of the neck and chest in salt water night and morning, following this with friction.

Unhealthy Wounds.—Solution of chlorinated soda mixed with water in various strengths makes an excellent detergent and disinfectant gargle, lotion, or injection, but is rather a preparation of chlorine than of soda.

Corneal Opacity.—Mr. Henry Power has recorded good results from the local application of powdered sulphate of soda to the cornea, though it is liable to cause severe irritation for a time (Practitioner, Sept., 1868).

Lupus.—The acetate of soda, though not often used, has remarkable power in lessening the granulation and crusting of strumous and lupoid ulceration: a lotion containing from 10 to 20 gr. in the ounce of water may be applied on compress, or injected into sinuses. In lupus the solid crystals may be lightly applied for a caustic effect (Anderson, Lancet, ii., 1869).

Pruritus—Eczema, etc.—In several forms of skin-disease, attended with itching, lotions containing a small proportion of carbonate or borate of soda, 1 to 2 dr. in ½ pint, are often serviceable. In urticaria, lichen, and the early inflammatory stages of eczema, when alkaline oozing occurs, the same lotion will give relief, but in the last case it should be made weaker still—20 to 30 gr. in the ½ pint; or, again, 20 gr. of the carbonate of soda may be usefully combined with an ounce of zinc ointment. In several forms of papular and scaly eruptions, such as *lichen* and *psoriasis*, baths containing about 4 to 6 oz. of carbonate of soda are very useful, being sedative as well as detergent. For common *chilblains* a strong solution of salt in water is a good domestic remedy; borax with glycerine is also good.

A weak lotion of borax is also often useful in cases of ordinary *sore nipple;* Sir Astley Cooper commonly prescribed it with spirit of wine. For slight cases of fissured *sore tongue* or buccal irritation, the glycerine of borax is pleasant and efficient.

Tinea Versicolor and even mild cases of tinea tonsurans (ringworm) may be cured by the same remedy. For the irri-

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tation and scaling connected with so-called *pityriasis capitis* a lotion containing borax, camphor, and rosemary is a good application.

Aphthæ, etc.—Aphthous conditions affecting the mouth and fauces are often treated with borax mixed with honey or dissolved in glycerine; a solution of chloride will also succeed sometimes. Aphthous conditions affecting the vulva, and the very irritating "pruritus pudendi" in either sex, may be much relieved by warm lotions or by paints containing borax. Laycock has spoken well of the use of borax in *diphtheria* (Med. Times, i., 1858, p. 548), but we have more dependable remedies.

Acne Simplex.—A liberal use of soap with hot water is often necessary in this disorder, and a borax lotion is of service.

Burns.—In burns and scalds, especially of the first degree, a saturated solution of the bicarbonate, applied constantly on moistened cloth, quickly relieves the burning pain.

Dental Caries.—Toothache, connected with open carious teeth, may often be relieved by the local use of carbonate of soda (½ dr. in the ounce of warm water); it probably acts by neutralizing acid or irritant secretions (Duckworth, Practitioner, 1875).

Rheumatism—Gout.—Soda baths are also useful in relieving pains of rheumatic character in the joints and muscles. Basham recommended basic phosphate of soda in powder as a good application for enlarged and painful gouty joints (Med. Times, ii., 1848), and it has some advantage over liquid applications; it may be applied on moistened spongio-piline. Hot salt in flannel is often a convenient mode of applying warmth to rheumatic or painful parts: in similar cases Dr. H. Bennett used "soda poultices" (Times, ii., 1853, p. 502).[1]

Leucorrhœa—Cystitis.—Injections containing carbonate of soda (1 to 2 dr. in the pint) form a simple and often efficacious remedy in cases of vaginal leucorrhœa with white, alkaline discharge, and in chronic cystitis an injection of borax, glycerine, and warm water is very soothing. The silicate of soda has been lately recommended for the same purpose; it coagulates albuminous material, and is antiseptic (Ranking, i., 1873).

[1] Soda salts are, by some practitioners, given internally for rheumatism, like potash (*v.* p. 743): the use of the salicylate will be discussed under salicylic acid.

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Ascarides, etc.—A strong injection of salt into the rectum is an efficient cure for these parasites, and is best given with quassia or other bitter. Salt is also taken internally to prevent recurrence of thread or round worms, and so strong at one time was the belief in its efficacy, that an ancient law in Holland deprived certain criminals of salt in their diet, in order to allow intestinal worms to develop and devour the victims!

Leeches are very sensitive to the action of salt; it will make them disgorge blood they have swallowed, and a saline injection will dislodge them from the rectum or vagina. It is advisable to administer the same remedy freely should they by accident have passed from the nose or mouth to the stomach.

Fractures, etc.—The silicate of soda (water-glass) is used like the analogous salt of potash. Bandages soaked in the fluid harden into a light firm support in twenty-four to forty-eight hours.

THERAPEUTICAL ACTION.—*Internal.*—Comparing soda with potash, we find the former more indicated in disorders of the stomach, the primæ viæ, and the liver, whilst the latter, acting better as a diuretic and a solvent of uric acid, is more appropriate in renal congestions and lithiuria.

Dyspepsia.—Soda salts are very useful in several forms of indigestion, but the dose and mode of administration vary somewhat according to the conditions present. In cases of *atonic* dyspepsia connected with deficient secretion of gastric juice, the bicarbonate in small doses of 5 to 10 gr. should be given, and shortly *before* a meal, on the principle already alluded to, viz., that an alkali causes increase of an acid secretion, for though on first contact it neutralizes the acid it meets with, additional acid is very quickly poured out so as to leave an excess. The alkali may, in some cases, be very suitably combined with an aromatic, as in "Gregory's powder," with ginger only, or with a bitter like tincture of orange or infusion of gentian. On the other hand, in cases of *acid* dyspepsia, with thickly coated or red shining tongue, sour eructations, heartburn, and flatulence, larger doses of the bicarbonate (15 to 20 gr.) should be given an hour or more *after* a meal, according to the time at which the symptoms

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come on; in this case, also, the remedy may be well combined with an aromatic or stimulant, as ammonia or peppermint. Soda is especially useful for the dyspepsia of those who live in towns, eating and drinking freely, and taking little exercise. If the urine be scanty and irritating, nitre may be given at the same time, and according to Dr. Budd, an occasional blue pill. A dry skin and very furred tongue are other indications for soda, whilst for those who live in the country, take more vegetable food, and perspire freely, acids usually agree better (Med. Times, i., 1854). If large doses of soda be continued too long, or taken at the wrong time, "it becomes a contest between the stomach and the doctor."

The familiar use of salt is of no small importance in stimulating appetite and digestion, and advantage is sometimes gained by varying the kind used: thus, Maldon salt is in crisp flakes, Lymington salt in deliquescent cubes, etc. (Med. Times, i., 1864). The principal ingredient in Vichy water is the bicarbonate of soda, but it contains minor or minute quantities of sulphate, phosphate, arseniate, borate, and chloride: this saline water may be very useful in simple *slow* digestion, with constipation and loss of appetite, and when gastralgia is not a prominent symptom (H. Weber, Med. Times, ii., 1861). Dr. Symonds states that "duodenal dyspepsia," with its attendant "bilious headache," may often be obviated for a long period by the daily taking of a tumblerful of "salt and water" before breakfast (Med. Times, i., 1858). An effervescent soda carbonate, or sulphate, is often efficacious in such headaches.

Lientery.—In the lientery of young children, Rabuteau has found salt curative after other remedies had failed (op. cit. p. 104).

In **Vomiting or Diarrhœa** connected with acidity, or with incomplete digestion of fatty food, the bicarbonate of soda, with an aromatic, such as cinnamon, is very good. In children with coated, irritable, or aphthous tongue, it may be combined with a little grey powder, and for adults, especially if colic is present, it may be given in effervescence with opium. In cases of dyspepsia, etc., in weakly subjects, the use of alkalies must not be too long continued.

Hepatic Disorders.—For congestion of the liver, with deficient secretion of bile, soda is of proved value in several com-

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binations, and it relieves such symptoms as have been already described under dyspepsia.

Phosphate of soda especially is said to promote the flow of bile, and acting in full doses as a gentle laxative, it is useful in "bilious or sick headache," and in catarrhal jaundice. It has some value, also, in preventing biliary calculus, which condition arises generally from continued catarrh of the bile-duct and inspissation of mucus and bile. (Vichy water presents a good natural combination for such cases and for chronic hepatic congestion). The salt cannot be expected to control fully-developed attacks of biliary colic, but if a dose of 20 or 30 gr. be taken regularly before meals for some months, it seems to have the power of lessening the calculi, or preventing fresh formations (Bartholow, p. 80); from larger doses (1 to 2 dr.) of the carbonate in copious draughts of hot water, Dr. Prout has often seen immediate relief even during the attack of colic.

In *fatty degeneration of the liver* we have the authority of Dr. Murchison for saying that large quantities of common salt, eaten with the food, have proved useful, and there is at least encouragement to try saline waters in this condition (Clin. Lect., p. 51). In the case of ill-conditioned children passing pale and pasty stools, 5 or 10 gr. of the phosphate taken with meals, will often serve to regulate digestion and improve nutrition (Stephenson).

Renal Diseases.—In cases of calculous (uric acid) diathesis, if it be desired to keep the system under the continued influence of alkalies, the salts of soda have sometimes been preferred in weakly dyspeptic subjects, being less depressing than those of potash commonly used. The waters of Vichy have a special reputation in such conditions, and under their influence a urate of soda replaces uric acid in the urine, and is more readily eliminated. The phosphate was especially commended by Liebig and by Golding Bird as a solvent of lithic deposit.

In **Albuminuria** it has been recommended to supply alkalies freely to the blood in order to lessen the liability to inflammation, and to dissolve fibrinous deposits. It has been taught also that they further the oxidation which is deficient in this dyscrasia, but they can only do so in a slight degree, if at all. Soda, like other alkalies, may be occasionally useful in

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relieving the dyspeptic symptoms, but is no cure for albuminuria, and its prolonged use is contra-indicated by the tendency to anæmia.

Diabetes.—Speaking not of the temporary and accidental passage of sugar into the urine, but of the more permanent malady, diabetes, we find that small doses of bicarbonate or of chloride of sodium often lessen the amount of sugar passed (Clarke of New York, and others).

The citrate, ½ to 1 dr., used, instead of common salt, with the food, is said "to cure saccharine urine" (Ranking, ii., 1866), and alkaline waters have been largely used in the treatment of this condition. At Vichy and similar springs it is found that stout diabetics derive advantage from the waters, when thin and pale patients do not. Transitory cases, such as have arisen from temporary nerve-causes, from carbuncle, etc., often do well at Vichy, and even old-standing cases have been relieved, but those with marked lesion of the pulmonary or digestive organs are not suitable for this treatment.

Ebstein reports favourably of Carlsbad and other alkaline waters, especially for mild cases (Med. Times, i., 1875). According to the theory of Mialhe, they should help to oxidize —burn up—sugar in the system, but their use cannot be based on this hypothesis. Poggiale fed dogs with non-nitrogenous food—starch and sugar—to which he added enough soda to render alkaline the urine, but their blood contained as much glucose as that of dogs fed without any soda; also he injected glucose into the blood of rabbits, and again injected it mixed with soda, in each case finding sugar in the urine, whilst under tartaric acid the sugar disappeared (Bull. de l'Acad., 1866, cf. p. 761). Bouchardat, on the other hand, points out that alkalies may act dangerously in increasing both fluidity of the blood, and tendency to apoplexy or pulmonary congestion, and Rabuteau cites several cases that died soon after commencing Vichy treatment. He suggests that whatever benefit is derived from soda salts is really due to the chloride, and according to Nasse and others this salt is deficient in the blood of diabetic patients. Martin Solon (Bull. Gén., 1842–43), Constant (Thèse, 1844), and Bouchardat have reported some clinical illustrations of the good effects of salt given as medicine to such subjects.

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Struma—Phthisis.—Some writers have much insisted on the therapeutical virtues of salt in these diseases. Durand Fardel reported instances of benefit, and Amedée Latour reduced its administration to a system; he gave it to well-fed goats, and then used the goats' saline milk largely in the diet of his patients; he employed also all hygienic means, and obtained good results (Union Méd., 1851–56, Brochure, 1857). Piétra Santa is another advocate for the systematic use of salt in phthisis, recommending a "syrupus natrii chlorati." Dr. Cotton, however, could not trace any definite effects from salt in his treatment at Brompton Hospital. The saline baths of Soden, in Nassau, have a reputation in similar cases, and in *obstinate chronic catarrh* the waters of Ems are often prescribed with advantage.

Intermittent Fever.—There is evidence of a favourable influence being exerted by salt in ague and some of its complications. Piorry used it, and Gintrac gave 30 grammes daily with success, except in quartans; he did not verify reduction of the spleen (Bordeaux, 1850), but Herschel and Rondelet have done so after a more prolonged use of the remedy. At Bruges, forty-eight cases were reported, and all of them, except the quartans, were convalescent in three to four days, after taking from 30 to 45 grammes of salt daily, freely diluted; it cleansed the furred tongue and improved appetite. Out of fifty-two cases reported from Africa the greater number were cured with 15-gramme doses of salt (Union Méd., 1851), and Villemin states that, according to his experience at Damascus, common salt stopped attacks of ague six times out of every seven, ½-oz. doses being given two, three, or four times (Gaz. Hebdom. de Méd., March, 1854). Mareschkin, a Russian physician, has recently given further evidence to the same effect (Bull. Gén. de Thérap., vol. li., p. 183).

Cholera.—The carbonate of soda has been used both by the stomach and by injection in cases of cholera, but the chloride has been more depended upon.

A reasonable argument may be given for its employment, for a main fact in the disease is profuse discharge by osmosis from the vessels of the intestinal tract into the alimentary canal; this by itself can determine the cyanosis, shrunk features, blood

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stasis, etc. It depends upon a change in the albuminous constituents of the blood, and is increased by desquamation of intestinal epithelium, whilst by saline injections the physical conditions may be so far altered as to lessen such osmosis. Both rectal and venous injections have been used, and benefit also has been traced to salt given by the mouth in cases when the power of absorption has been retained.

During an epidemic at St. Petersburg (1830) salt water and salt milk relieved as much as any other remedies. In 1835, at Paris, Bracton reported fifty cases of Asiatic cholera treated with common salt, and only one was fatal;—two table-spoonfuls were given dissolved in 6 oz. of water. Chomel, Aran, Richard, and others reported good results from the same treatment in the epidemic of 1865. On the other hand, Husemann concludes that the use of salt has no really good effect, and states that its intravenous injection has sometimes caused asphyxia. The question cannot yet be considered decided.

For **Dysentery**, the sulphate of soda has been much commended by American writers: 1 dr. is given with $\frac{1}{6}$ gr. of morphia every two hours, until natural, though loose, evacuations occur; this treatment is said to control the malady in two or three days (New York Med. Record, Feb., 1872).

Constipation.—On the other hand, the same remedy (soda sulphate), when given in larger doses of $\frac{1}{2}$ oz., is a useful saline purge in inflammatory conditions, and is an ingredient in several natural aperient waters: if given with sulphate of magnesia or acid tartrate of potash, smaller doses (1 to 2 dr.) may be used. The phosphate of soda acts in the same manner on the intestinal tract, and has a more decided diuretic action; it renders the urine alkaline. Tartarated soda is an ingredient of Seidlitz powders.

Uterine Inertia.—Borax has some stimulating effect upon the uterus, as shown by its increasing contraction during labour: it has been used in lingering cases, though generally combined with ergot and cinnamon; it is nauseous in taste. Borax has been given also in *amenorrhœa*, with or without aloes, and in *dysmenorrhœa* with belladonna, but is not in general use. Since this is the only soda salt that acts upon the uterine system, it probably does so through the boracic acid.

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Epistaxis—Embolism.—Common salt is an ordinary domestic remedy for bleeding at the nose, and even for hæmoptysis, and cases of the former are sometimes favourably influenced by it when given in drachm doses. Some attribute any benefit from salt in hæmorrhage to the nausea excited, but it is more likely from a reflex contraction of vessels consequent on irritation of gastric nerves (Husemann). It has been stated that in *embolism*, the collateral circulation becomes better established under the influence of an alkali (soda carbonate), though the thrombus itself is not affected (Brit. and For. Rev., ii., 1861).

PREPARATIONS AND DOSE.—*Liquor sodæ:* dose, 10 to 60 min., freely diluted. *Soda caustica. Sodæ carbonas:* dose, 10 to 30 gr. or more. *Sodæ carbonas exsiccata:* dose, 5 to 15 gr. *Sodæ bicarbonas:* dose, 10 to 60 gr. *Liquor sodæ effervescens —soda water:* dose, 2 to 10 oz. or more—each pint contains 30 gr. of bicarbonate of soda. *Trochisci sodæ bicarbonatis:* dose, 1 to 6—each lozenge contains 5 gr. *Sodæ arsenias* (*v.* Arsenic). *Sodæ sulphas:* dose, ¼ to 1 oz. *Sodæ acetas:* dose, 20 to 60 gr. *Sodæ sulphis* (not officinal): dose, 20 to 60 gr. (*v.* Sulphurous Acid). *Sodæ hyposulphis* (not officinal): dose, 20 to 60 gr. *Sodæ nitras* (for making the arseniate). *Sodæ phosphas*: dose, as a *diuretic*, 30 to 120 gr.; *purgative*, ½ to 1 oz.—given in mutton broth it is almost tasteless. *Sodæ hypophosphis*: dose, 5 to 10 gr. (*v.* Phosphorus). *Borax:* dose, 10 to 60 gr. *Mel boracis:* contains 54 gr. of borax to 1 oz. of honey. *Glycerinum boracis:* contains 1 part to 4. *Liquor sodæ chloratæ:* dose, 10 to 20 min. internally, diluted with 1 or 2 oz. of water; as gargle, ½ to 1 oz. to ½ pint water. *Cataplasma sodæ chloratæ* (solution of chlorinated soda 2 oz., linseed meal 4 oz., water 8 oz.). *Sodii chloridum:* dose, ½ oz. or more as an emetic. *Sodæ tartarata* (*Rochelle salt*): dose, as a *diuretic*, 30 to 60 gr.; *purgative*, 2 to 4 dr. *Sodæ citro-tartras effervescens:* dose, 60 gr. to 2 dr. *Sodæ valerianas* (*v.* Valerian).

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STANNUM—TIN, Sn, = 118 (not officinal).

This metal is known to occur only in the mineral kingdom, and in minute quantity in the water of Saidschütz.

CHARACTERS AND TESTS.—Silver-white in colour, with a tinge of yellow, and high metallic lustre, unaffected by moisture or exposure, inelastic, but flexible; when rubbed it imparts to the fingers a peculiar odour. It is a good conductor of heat and electricity, has a sp. gr. of 7·292, melts at 442° F., and at a higher temperature burns with a brilliant white light; at ordinary temperatures it is not brittle, but when heated to near the fusing point may be easily powdered. Nitric acid does not act upon it, except in presence of water; hydrochloric acid dissolves it with evolution of hydrogen.

Solution of *chloride of tin*, $SnCl_2$ (Appendix, B. P.), absorbs oxygen readily, and hence is a powerful deoxidizing agent. It reduces to the metallic state the salts of mercury, silver, gold, etc., and is made use of for this purpose; also as a test for ammoniated mercury.

PHYSIOLOGICAL ACTION.—*Internal.*—The metal itself is inert, but if taken into the stomach may be so far acted on by acids or saline substances as to be rendered soluble in the form of chloride, and may then produce some irritant effects. The fact of such a change sometimes occurring, and sometimes not, may explain the disagreement between the results of Orfila, who considered oxide of tin to be a poison, and Schubarth, who considered it inert.

It has been said that fatty, or acid, or simply albuminous articles of food, after having been kept in tinned vessels (free from lead) have sometimes occasioned colic and vomiting, but this must be exceptional. We may note that arsenic is a usual constituent of tin-ores, and in small quantity it is generally present in all tin that has not been carefully purified, and irritant effects may have occurred from it (Gubler).

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The *chloride*, or "*butter of tin*," is stated to exert a tonic, anti-spasmodic effect, when given in small quantities, but in large doses it causes muscular twitching, convulsion, and paralysis; also some gastro-intestinal irritation, with dryness of mouth and throat.

THERAPEUTICAL ACTION—Intestinal Worms.—The powder of tin (tin filings) has been used as a vermifuge in cases of lumbricus and tænia.

Trousseau remarks that of all metals after mercury, tin has been in the highest repute as anthelmintic, and many secret vermifuges contain either the finely-powdered metal or its sulphide: from 30 gr. to ½ oz. have been given in electuary. Alston gave 1 oz. at a time, but severely irritant effects sometimes followed. Professor Stillé quotes several authorities in favour of the remedy, and Dr. Graves speaks well of it (Lectures, ii., p. 248), but it is not now much used, because more dependable medicines have been found. It is supposed to act either mechanically or by disengagement of hydrogen or other chemical effects. Salts of di-stann-ethyl have a strong purgative action (Jolyet and Cahours).

In **Epilepsy, Chorea**, and allied forms of nerve-disorder, the chloride of tin has been given with benefit, according to the observations of Dr. Schlessinger (Med.-Chir. Rev., Oct., 1838, and April, 1846).

In **Chronic Skin-Diseases**, the same physician recommends it both internally and in lotion, but its real value is not ascertained.

PREPARATIONS AND DOSE.—*Pulvis stanni* (not officinal): dose, 20 to 40 gr. as a vermifuge—it may be given in honey or treacle three or four times daily for several days, and should then be followed by a cathartic. *Stanni chloridum:* dose, $\frac{1}{10}$ to ½ gr. two or three times daily in pill or in chloric ether—*a lotion* may be made with 1 gr. to the ounce.

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ZINCUM—ZINC, Zn, = 65.

This mineral is obtained, for commercial purposes, mainly from two ores—the carbonate (calamine) and the sulphide (blende)—by distillation with carbon. It has been found also in plants which grow on the calamine hills of Rhenish Prussia. It is liable to contain arsenic, iron, copper, and sulphur. Alloyed with copper, zinc forms brass, with nickel, "German silver." It is extensively used in galvanic combinations, and forms the positive plate of many voltaic batteries; as a coating on iron (galvanized iron) it protects from oxidation. Granulated zinc is prepared by pouring the molten metal into cold water.

CHARACTERS AND TESTS.—Zinc is a brittle bluish-white metal, which at a red heat burns with a brilliant flame, and emits white fumes of oxide; sp. gr. 7. It is the only metal which yields a white sulphide with sulphide of ammonium, and hence this reaction is the characteristic test for it. Fixed and volatile alkalies also give with zinc white precipitates, soluble in excess of the reagents.

COMPOUNDS OF ZINC.

ZINCI OXIDUM—OXIDE OF ZINC, ZnO, = 81.

PREPARATION.—By exposure of the carbonate to a dull red heat until all the carbonic acid is driven off. "Hubbuck's" oxide of zinc is obtained by combustion of the metal in air.

CHARACTERS AND TESTS.—A white heavy powder, without taste or odour, insoluble in water, soluble in acids; moderate heat renders it yellow. Commercial specimens are often impure from presence of carbonates, sulphates, chlorides, iron, etc.

ZINCI CHLORIDUM—CHLORIDE OF ZINC, $ZnCl_2$, = 136.

PREPARATION.—By dissolving zinc in hydrochloric acid, and evaporating the solution; chlorine water is then added (to

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combine as chloride with the iron usually present), and afterwards zinc carbonate, which forms more zinc chloride and precipitates ferric oxide.

CHARACTERS.—Chloride of zinc is soft, white or semi-transparent, crystalline or waxy, and is met with either in opaque tablets or in pencils like nitrate of silver. It is very soluble and deliquescent, but if mixed with an equal part of oxide (oxychloride), may be kept dry for a long time.

ZINCI SULPHAS—SULPHATE OF ZINC—WHITE VITRIOL, $ZnSO_4 7H_2O, = 287.$

PREPARATION.—By dissolving zinc in dilute sulphuric acid: chlorine water and carbonate of zinc are added, as in the last preparation, and for the same purpose, viz., to remove any iron that may be present.

CHARACTERS.—Occurs in prismatic crystals, which may be large or small. The latter much resemble in appearance those of sulphate of magnesia, but their strong styptic taste will distinguish them from the bitter magnesian salt (*v.* p. 684): they redden litmus and effloresce in air.

ZINCI CARBONAS—CARBONATE OF ZINC, $ZnCO_3(ZnO)_2 2H_2O, = 341{\cdot}4.$

PREPARATION.—By adding carbonate of sodium to a boiling solution of sulphate of zinc, and drying the precipitate; if cold solutions be used, the precipitate is gelatinous. (The compound formed is really a hydrated oxycarbonate, as in the formula.)

CHARACTERS.—A soft, white powder, resembling magnesia, insoluble in water, tasteless and inodorous. The native impure carbonate (calamine, lapis calaminaris) was formerly officinal, but the pink powder sold under that name was almost always spurious, consisting of barium sulphate coloured with iron.

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ZINCI ACETAS—ACETATE OF ZINC, $Zn(C_2H_3O_2)_2\,2H_2O$, = 219.

PREPARATION, etc. — By dissolving the carbonate in acetic acid. Occurs in thin, lustrous, micaceous plates, having a sharp astringent taste.

ZINCI VALERIANAS—VALERIANATE OF ZINC, $Zn(C_5H_9O_2)_2$, = 267.

PREPARATION.—By mixing concentrated solutions of sulphate of zinc and valerianate of sodium.

CHARACTERS.—Occurs in brilliant scaly crystals, which have an odour of valerian, and a metallic taste; soluble slightly in cold water or ether, freely in hot water and in alcohol. It is liable to be contaminated with butyrate of zinc.

ABSORPTION AND ELIMINATION.—Soluble salts of zinc, such as the *chloride*, *sulphate*, and *acetate*, are readily absorbed, and pass into the blood probably as albuminates. The *oxide* and the *carbonate* are also dissolved to some extent by the acids of the gastric juice, and then slowly absorbed; independently of clinical evidence of this, the oxide has been detected by Schlossberger in the urine, and by Michaelis in venous blood.

Zinc does not seem to be deposited in the tissues in the same manner, or for so long a period, as mercury, lead, or copper, although recently Lechartier and Bellamy have detected it in the bodies of animals to whom the metal had been previously administered (Med. Record, i., 1877). The soluble salts are eliminated soon after being taken, but the insoluble ones are not found in the excretions until four or five days afterwards (Michaelis). The metal passes out mainly by the bile and the intestinal secretions; in smaller amount by the urine.

PHYSIOLOGICAL ACTION.—*External.*—The oxide and the carbonate of zinc, in powder, act mechanically as absorbents and sedatives. The sulphate and the acetate, in the solid state, act as efficient, but not very severe, caustics, if the epidermis be removed: in dilute solution they act as astringents. The chloride and nitrate exert a strongly caustic effect by virtue of their

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affinity for water, and their power of coagulating albuminous material; the former especially, being deliquescent, penetrates deeply into the tissues, and causes severe burning pain; the eschar produced is white and hard, and separates in five or six days; when formed from deep tissues it is of spongy character, but dry on exposed surfaces. Zinc chloride is a powerful disinfectant, and even in dilute solution proves fatal to germs, vibriones, etc.; according to Calvert's experiments, it is only equalled in efficacy by mercurial chlorides and the tar acids (Lancet, ii., 1873, Med. Times, ii., 1852, p. 101).

PHYSIOLOGICAL ACTION.—*Internal.*—**Digestive System.**—The oxide and carbonate, in doses of a grain and less, exert an astringent and somewhat sedative action on the gastro-intestinal tract, markedly lessening its secretions. The sulphate, in small non-irritant doses, is still more astringent. All zinc compounds have a tendency to excite nausea and irritation of the stomach; the oxide and the carbonate, though tasteless, show this effect when given in doses of from 1 to 5 gr. and upwards. The soluble salts have a styptic metallic taste, and the sulphate, in doses of 5 to 10 gr. and upwards, acts as a prompt and thorough emetic without much nausea or prostration, though often with diarrhœa: this action is not purely a local one, because it is equally produced by intravenous injection of the salt. Emesis, however, is not a constant effect, for if the drug be taken at first in small doses and continued regularly, a certain tolerance is established, and then 10 to 20-gr. doses may be taken without disorder of the stomach. Caution is required in the continuance even of small doses, since they have been said to cause ulceration of mucous membrane, and ultimately symptoms like those of lead-poisoning, such as emaciation, anæmia, debility, fœtor of breath, constipation, and colic, also tremor, paralysis, etc. Symptoms of acute irritant poisoning, such as pain, vomiting, convulsion, and collapse, have followed doses of 30 to 60 gr., and sometimes concentrated solutions have caused death (Med. Times, ii., 1862, p. 252), but the salt has rarely proved fatal, because of its being so soon rejected; persons have recovered after taking an ounce or even more.

The chloride is much more corrosive in character, and is

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unsuited for internal use—5 to 10 gr. have produced severe irritant symptoms. It has been a not infrequent source of fatal poisoning in the form of Sir W. Burnett's disinfecting fluid, which is an impure solution of it, somewhat oily in character, and either colourless or of yellowish tinge, from the presence of some ferric oxide: it has been mistaken for fluid magnesia, for mineral waters, and for pale ale, the fact of its frothing up when shaken contributing to its resemblance to the last-mentioned: one fl. oz. has been found to contain from 100 to 372 gr. of solid chloride (Taylor), 200 gr. (R. W. Smith), and less than that quantity has proved fatal, though not invariably.

Nervous System.—The oxide of zinc has been credited with a special action on the nervous system, of tonic character in small, but depressant in large doses. Dr. Marcet traced drowsiness to its use, and others have recorded giddiness after taking it, and generally depressed nervous and mental conditions from the prolonged continuance of large doses (Med. Times, 1858, Med.-Chir. Rev., ii., 1861). In cases of ultimate recovery from the effects of large doses of zinc salts there have been, besides the gastric symptoms, signs of impaired nerve-power, with perversion of taste and smell, tremor, or partial paralysis. Exposure to fumes of the molten metal, as in the course of certain metallic castings, gives rise to a curious train of symptoms, mainly nervous, and commonly known as "brass-founders' ague," and including general malaise, tightness of chest, a cold stage with rigors, followed by a hot stage with profuse sweating. These symptoms may recur periodically for several days (H. Greenhow, quoted Lancet, i., 1863—*v.* p. 541).

Cutaneous System.—The internal administration of the oxide or other astringent zinc salts checks the secretions of the skin.

SYNERGISTS.—The oxides of silver and of bismuth are much allied in action with oxide of zinc: henbane and belladonna promote its power of controlling perspiration (*v.* p. 785). The chloride of zinc resembles in corrosive and disinfectant properties the chloride of mercury, and both the chloride and nitrate are allied in action with other mineral caustics.

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ANTAGONISTS.—The chemical antidotes in cases of poisoning by the corrosive compounds of zinc are lime-water, alkaline carbonates, and tannic acid; these should be given in mucilage or milk. Valerianate of zinc is decomposed by acids and by most metallic salts. Purgatives and diaphoretics interfere with the action of zinc salts.

THERAPEUTICAL ACTION.—*External.*—**Lupus—Cancer, etc.**—The chloride of zinc was first introduced as a secret remedy for cancer by Canquoin in Paris, in 1837, and was combined with sanguinaria in the paste of Dr. Fell, which had a temporary popularity (Med. Times, i., 1858, p. 11). Veiel recorded excellent results from its use in lupus (Med.-Chir. Rev., ii., 1860), and it is certainly a very reliable escharotic. I have seen immediate improvement from it, in some very severe cases, especially of facial lupus and rodent ulcer. It has disadvantages in being deliquescent, and hence readily penetrating adjacent healthy tissues and disposing to hæmorrhage, but when mixed with flour, zinc oxides, or better still with lime sulphate or gutta-percha, it becomes quite manageable. The nitrate of zinc, though not in such frequent use, has, perhaps, advantages over the chloride; according to Mr. Marshall, it penetrates deeper, and causes less pain: in lupus it was commended by Dr. Tilbury Fox, and I have had very successful results with it, generally using a paste made with equal parts of nitrate, flour, and mucilage spread on lint.

Both this salt and the chloride are equally applicable to all forms of strumous and syphilitic ulceration. Franchi reports arrest in some very severe cases of this kind, when acid nitrate of mercury, iodine, etc., had been tried without success (Gaz. Méd. de Paris, Feb., 1876). Maisonneuve used the chloride made into firm paste with flour in the form of flèches ("arrowheads"), which he thrust into incisions all round a morbid growth, thus destroying a zone of tissue and separating the tumour; but this process is more painful and prolonged than the use of the knife, and does not prevent recurrence better than an equally extensive incision.

Sir J. Y. Simpson advocated sulphate of zinc in powder as the best caustic for these maladies, whether affecting the uterus or

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other parts: it is simple, easily applied and managed, safe, efficient, fairly rapid in action (five or six days), and does not deliquesce. In cases where the epithelium was destroyed, he applied the anhydrous salt in fine powder or mixed with glycerine into a paste (1 oz. of sulphate to 1 dr. of glycerine). In other cases, *e.g.*, of cancer of the breast, he mixed the salt with sulphuric acid and scored the part with a quill at successive applications (Med. Times, i., 1857, and 1859); he records many good results, which were to some extent corroborated, but his practice has not been largely followed. Mr. Erichsen found it very painful (Med. Times, i., 1857, p. 238).

Warts—Nævi.—The strong chloride is useful for destroying warts and superficial nævi. Mr. Weeden Cooke has suggested a convenient mode of applying it, viz., by soaking lint in the deliquescent salt, drying it, and cutting off suitable pieces when required: if covered it will preserve its power for many weeks (Med.-Chir. Rev., Jan., 1866).

Wounds.—Mr. C. de Morgan, and others, recommended the sponging of recent wounds, whether from accident or operation, with strong solutions of zinc chloride (20 to 40 gr. in the ounce) on disinfectant principles, *i.e.*, to destroy "germs" (Lancet, i., 1866, Med.-Chir. Rev., Jan., 1866). This seems to have good effect in lessening risk of septicæmia, etc., but has in a measure been superseded by the more detailed and exact method of Lister. It is, however, still largely used, and is valuable in many cases, especially where Listerism cannot be carried out: it cleanses the wound and any old sinuses, and lessens and prevents suppuration. Some surgeons employ it especially after excision of malignant tumours.

Eczema—Erythema.—The oxide and the carbonate of zinc, and "calamine" (impure native carbonate), form useful sedative, absorbent, and protective powders for inflamed surfaces, and sometimes are indicated when serous discharge is present: they are generally mixed with ¼ or ½ part of a neutral powder, such as that of orris-root, starch, or magnesia. They may be used also suspended in mucilaginous liquids as a good lotion, *e.g.*, for erythematous acne of the face, or in the form of ointment mixed with oleic acid—oleate of zinc—(Crocker, B. M. J., i., 1879), or vaseline, or the benzoated lard of Mr. Erasmus Wilson: benzoated zinc ointment, when properly

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made, is an excellent application for irritative and eczematous conditions. A lotion containing 5 gr. of sulphate in the ounce, relieves the itching of eczema and other skin-diseases, but is liable at first to cause some smarting.

Relaxed or Discharging Mucous Surfaces.—For ordinary relaxed or discharging surfaces, when astringents are indicated, the sulphate of zinc is one of the best: from 1 to 2 gr. in the ounce of distilled water is a usual strength, and combined with a stimulant, such as spirit of rosemary or lavender, this forms the ordinary "red lotion" of many hospitals, and is suitable for any indolent atonic ulcerations: sulpho-carbolate of zinc also forms a good detergent lotion (Lancet, ii., 1868, p. 763).

For catarrhal *throat-affections* accompanied with deafness, Dr. Druitt finds zinc sulphate in solution act better than ordinary acid gargles, and Mr. Nunn reports similarly as to the chloride (Med. Times, i., 1857, pp. 210, 247): a spray containing this is excellent for relaxed pharynx and congested vocal cords.

In catarrhal *conjunctivitis*, and *otorrhœa*, collyria and weak warm injections of the same salts (2 gr. to the ounce of water) are useful, and 4 gr. to the ounce is a good strength for injection in *ozæna;* morphia, atropia, or carbolic acid may be combined with the astringent.

The chloride lotion is also valuable in *gonorrhœal* and *purulent ophthalmia*, and Mr. Hutchinson reports it as less painful than silver nitrate, and sometimes completing the cure when that remedy failed (Lond. Hosp. Rep., 1867-68).

In *leucorrhœa* and *gonorrhœa*, injections containing 1 to 2 gr. of zinc sulphate or sulpho-carbolate to the ounce, are very suitable after the early acute stage has subsided (Med. Times, ii., 1870, p. 454, etc.); they are sometimes better combined with an equal quantity of lead acetate. As a general rule, the more acute the condition, the more frequently should a weak solution ($\frac{1}{2}$ gr. or less in the ounce) be applied, and as the inflammation becomes less or passes into a chronic stage, one or two applications daily of a double or treble strength are best. Some time ago I recommended to Dr. Ringer's notice the prescription of a very dilute injection of sulphate (1 to 2 gr. in the *pint* of water) to be used every hour or half-hour from the commencement of a gonorrhœal attack, and his experience supports mine, that this can arrest the

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disorder in twenty-four to forty-eight hours; care is required so as to avoid risk of pain and swelling of the testicles, *i.e.*, the injection must be used less often, or left off, if any such symptoms set in. A stronger solution (1 to 10 gr. in the ounce) is advisable, but used less frequently, in more chronic cases (Lloyd, Lancet, ii.,1850, W. Cooke, Med. Times, i., 1860, p. 127). The chloride, and indeed many other astringent salts, may be used in a similar manner with advantage.

THERAPEUTICAL ACTION. — *Internal.* — **Narcotic and other Poisoning.**—Zinc sulphate is a good emetic for cases of this kind: 10 gr. in warm water is an average dose, but 20 gr. is the amount preferred by many practitioners; if the mouth be firmly closed, it may be administered by a tube passed through the nose to the gullet, or by the stomach-pump through a gag, and if the larger dose be used, its after-rejection must be secured. When an emetic is given by the stomach, its bulk has an effect in securing the result: thus, the greater quantity of warm water that can be given with the zinc sulphate the better it will act: time also makes a difference, for smaller doses given slowly have acted better than large ones quickly swallowed. In some cases a few grains have been given by intravenous injection, and have produced emesis.

Gastralgia—Diarrhœa.—Prof. Gubler, having remarked the analogous effects of the oxides of zinc and of bismuth, suggested the substitution of the former when expense was an object, and experience has proved that the zinc compound will often act in an extremely satisfactory manner in relieving gastric pain, especially when this is followed by diarrhœa of undigested food; it has, however, more tendency to nauseate than the bismuth salt. The dose should commence at 1 gr., and not exceed 3 gr., and should not, as a rule, be given on an empty stomach.

In *dyspepsia* connected with oxaluria, Bartholow has found the sulphate useful, and Gillespie recommends it (Boston Journ., May, 1868).

Dr. Brakenridge, of Edinburgh, was one of the first to draw attention to the value of zinc oxide in *infantile diarrhœa* (Med. Times, i., 1873), and I have, in common with many others, found it an efficient and non-irritant astringent.

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In *chronic* diarrhœa, and even in *dysentery*, the oxide has acted very favourably (Bull. de Thérap., March, 1877), but the sulphate has more decided powers.

Bronchorrhœa.—Excessive secretion from the bronchial tubes is controlled by the oxide and by the sulphate of zinc (Barlow).

Hyperidrosis.—I can entertain no doubt of the power of zinc oxide to control excessive sweating in phthisis and other exhausting diseases, although it has been denied by some observers. Dr. T. Thompson, one of the first to record this effect, found it increased, as we should expect, by conjunction of the zinc with henbane extract—he prescribed 4 gr. of each substance (Med. Times, i., 1854, p. 190); and W. Curran and others have corroborated his observations (Lancet, i., 1854, ii., 1868). I generally order 1 or 2 gr. of the oxide with the same quantity of extract of henbane, to be taken at bed-time, and again in the course of the night if necessary.

Epilepsy.—The value of zinc salts in disorders of the nervous system has been much disputed, some physicians, as M. Herpin, recording extraordinary results from them, and others, as M. Gubler, denying to them any power.

There can be little doubt that the high estimate formed by M. Herpin of the efficacy of the oxide, and later of the lactate of zinc, in epilepsy, is unfounded—no other observer has verified his results—at the same time we cannot deny altogether their efficacy in some cases. Dr. Wilks has seen benefit from the oxide (Med. Times, i., 1869, p. 84), and Dr. Sieveking records successful results, though he does not value it highly. Dr. Russell Reynolds has known it serviceable, and Dr. Radcliffe, noting its effect in causing anæmia, suggests that it might best be tried in markedly congestive cases (Lancet, i., 1863). Others have thought it more applicable when the epilepsy was complicated with gastric disorder, and others again have seen the best results from it when used in conjunction with bromides or digitalis (Lancet, ii., 1868, Med. Times, ii., 1874, p. 481).

Charcot has observed benefit from the bromide of zinc (B. M. J., Nov., 1877), but Dr. Gowers, in his recent lectures, considers that salt of little value, and has found it badly borne. The oxide, however, in his experience, proved sometimes useful, relieving three cases out of ten submitted to it (Lancet, i., 1880, p. 553).

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Chorea.—There is much evidence as to the value both of oxide and sulphate of zinc in this malady, more perhaps in favour of the latter; it requires to be given in gradually increasing doses up to 15 to 20 gr. (Barlow). In recording many cases, all of which derived some benefit, Mr. Marsh, of the Children's Hospital, remarks that no definite indication for the sulphate could be verified, but that a harsh, dry skin became soft during its administration (Lancet, ii., 1871); it was well borne. In chorea affecting *strumous* children, I can speak well of the iodide of zinc. Dr. Barlow was the first to recommend it (Med. Times, ii., 1857).

Chronic Alcoholism.—Dr. Marcet made many observations on the treatment of this condition, and published a special essay to illustrate the value of zinc oxide in controlling the unsteadiness and the tremor which are its usual accompaniments (Chronic Alcoholic Intoxication, London, 1860, Lancet, i., 1859). Dr. Anstie accorded some, but not so much, value to the drug in the same conditions.

In **Hysteria** and **Debility**, if anæmia be not extreme, zinc salts often prove useful, but more especially when combined with other nerve-tonics: thus, Dr. Barnes speaks very favourably of zinc with phosphoric acid (phosphate of zinc) (Lancet, i., 1858, p. 119), and has recently re-stated his opinion as to its value in convulsive diseases of women (Lancet, i., 1873, p. 621). Vigier finds the phosphide of zinc acts more quickly than phosphorus itself (Bulletin, Jan., 1876), and the valerianate, although decried by many observers, certainly relieves in some cases. Zinc oxide may be combined with camphor, galbanum, sumbul, etc.

Spasmodic Cough—Asthma.—Both the oxide and the sulphate of zinc, especially in conjunction with belladonna, have been found to relieve spasmodic cough, whooping-cough, etc. (Fuller, Lancet, ii., 1860). In the intervals of spasmodic asthma, they are given as prophylactics (Symonds, B. M. J., i., 1868). The valerianate has been successfully used for obstinate hiccough and for hysterical cough (G. Harley, Med. Times, ii., 1863), but although of some value, is uncertain in its action. In laryngeal spasm, sometimes, 5 to 6-gr. doses will succeed when smaller ones fail (Med. Times, i., 1858, p. 475).

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Nervous Headache—Neuralgia.—The valerianate is valuable in nervous headache, and it is especially useful for cases of neuralgia connected with uterine derangement.

Tremor.—In tremor connected with mercurial and arsenical poisoning, Guéneau de Mussy found phosphide of zinc effective (Lancet, i., 1876, p. 208). I have tried it in the tremor of sclerosis, but without result.

Rheumatism.—Amongst the rarer uses of zinc salts may be mentioned that of the cyanide in articular rheumatism; it was strongly commended by Luton, as relieving pain and lowering vascular excitement (Bulletin, Jan., 1875). Other observers find it also of some, but not definite, value; it is apt to cause headache (Med. Record, i., 1877).

PREPARATIONS AND DOSE.—*Zinci oxidum:* dose, 1 to 10 gr. or more, in pill or powder. *Unguentum zinci:* made with oxide of zinc and benzoated lard. *Zinci carbonas:* dose, 1 to 10 gr., in pill or powder. *Zinci sulphas:* dose, as a tonic or astringent, 1 to 5 gr. or upwards, in pill or solution; as an emetic, 10 to 30 gr.; for an injection or lotion, from 1 to 10 gr. in the ounce of water. *Zinci acetas:* dose, 1 to 2 gr. as a tonic, 10 to 20 gr. as an emetic; as an injection or lotion, 1 to 10 gr. to the ounce of water. *Zinci valerianas:* dose, 1 to 5 gr. and upwards. *Zinci chloridum:* dose, ½ to 2 gr. *Pasta zinci chloridi:* made with flour and mucilage. *Liquor zinci chloridi*, B.P. (contains about 36 gr. in the fluid ounce, *v.* p. 780), not used internally. *Zinci nitras* (not officinal): used as a caustic in paste.

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INDEX.

REMEDIES.

A

Acetate of Ammonia, 324
alumina, 342
copper, 535, 551
iron, 556
lead, 704
potash, 724
soda, 755
zinc, 778
Acetic acid, 231
Acetum, 232
Acidum aceticum, 231
dilutum, 232
glaciale, 231
bromhydricum, 154
carbonicum, 236
citricum, 243
hydrochloricum, 246
dilutum, 256
nitro-hydrochloricum dilutum, 257
hydrocyanicum dilutum, 260
nitricum, 277
dilutum, 285
phosphoricum dilutum, 285
sulphuricum, 292
aromaticum, 300
dilutum, 300
sulphurosum, 301
tartaricum, 319
Ærugo, 535
Air, compressed, 8
Alumen, 341, 354
exsiccatum, 354
Aluminium, 341
Alûms, 341
Ammonia, 322
Ammoniæ acetatis liquor, 324
benzoas, 325
carbonas, 213
citratis liquor, 325
linimentum, 340
liquor, 323, 340
fortior, 323
nitras, 340
phosphas, 325, 340
spiritus aromaticus, 340
fœtidus, 340
Ammoniated mercury, 621
Ammonii bromidum, 126
chloridum, 324
iodidum, 77, 121
sulphidum, 325
Ammonio-citrate of iron, 559
Antimonial wine, 384
ointment, 384
powder, 384
Antimonii chloridi liquor, 356
oxidum, 356, 384
Antimonium, 355
nigrum, 355
sulphuratum, 355
tartaratum, 356
Aqua, 161

Digitized by Google

Aqua fortis, 277
Aqua Pagliari, 349
Argluti chloridum, 385
nitras, 385
oxidum, 385
Argentum, 384
Argol, 725
Aromatic mixture of iron, 615
powder of chalk, 530
sulphuric acid, 300
Arseniate of iron, 558
soda, 418
Arsenic, white, 416
Arsenicalis liquor, 417
Arsenici et hydrargyri hydriodatis liquor, 418
hydrochloricus liquor, 417
Arsenicum, 416
Arsenious acid, 416
Auri iodidum, 477
perchloridum, 476
peroxidum, 477
pulvis, 476
et sodii chloridum, 477
syrupus, 482
unguentum, 482
Aurum, 476

B

Barii Carbonas, 483
chloridum, 483
chloridi liquor, 486
Barium, 483
Baryta, 483
Bath, blanket, 173
cold, 161
douche, 165
foot, 167
hot, 169
mustard, 173
pack, 167
Russian, 171
shallow, 164
sitz, 166
spinal, 165
Bath, steam, 171
sulphur, 44
towel, 163
Turkish, 171
Bathing, sea, 193
Béchamp's preparation of iron, 617
Biborate of soda, 756
Bicarbonate of potash, 724
of soda, 754
"Bismuth-cream," 499
Bismuthi et ammoniæ citratis liquor, 488
carbonas, 488
oleas, 500
oxidum, 487
subnitras, 487
trochisci, 499
unguentum, 500
Bismuthum, 486
Black antimony, 355
Black oxide of manganese, 697
Blaud, pilule de, 616
Blue pill, 671
Bone black, 23
Borax, 756
Bromides, alkaline, 125, 126
Bromine, 121
Burnett's solution, 780
Burnt alum, 341
Butter of antimony, 356

C

Cadmii Bromidum, 502
iodidum, 502
iodidi unguentum, 504
sulphis, 502
Cadmium, 502
Calamine, 777
Calcii bromidum, 126
chloridum, 507
sulphidum, 28
Calcis carbonas, 506
hydras, 505
hypophosphis, 530
linimentum, 530

Digitized by Google

Calcis liquor, 530
saccharatus, 530
phosphas, 508
sulphis, 302
c. sulphure solutio, 43
Calcium, 505
Calomel, 619
Calx, 505
chlorata, 508
Carbo animalis, 23
purificatus, 24
ligni, 23
Carbonate of ammonia, 213
bismuth, 488
iron, 557
lead, 705
lime, 506
lithia, 676
magnesia, 684
manganese, 704
potash, 723
soda, 753
dried, 754
zinc, 777
Carbonic acid, 236
Carbonis cataplasma, 26
Caustic potash, 723
soda, 753
Cerii oxalas, 531
Cerium, 531
Chalk, mixture, 632
prepared, 530
Chalybeate waters, 227
Charcoal, 23
Chlorate of potash, 727
Chlorine, 154
Chlori liquor, 155
vapor, 160
Chloride of ammonium, 324
antimony, 356
calcium, 507
silver, 385
sodium, 757
tin, 775
zinc, 776
Chlorinated lime, 508
Cinnabar, 623
Citrate of ammonia, 325
bismuth and ammonia, 488
iron and ammonia, 559
and quinine, 559
lithia, 676
magnesia, 696
potash, 724
Citric acid, 243
Compresses, 168
Copperas, 535
Corrosive sublimate, 620
Cosme's paste, 655
Cream of tartar, 725
Creta, 530
Cupri acetici tinctura, 551
ammonio-sulphas, 535
subacetas, 535
sulphas, 535
Cuprum, 534

D

De Valangin's Solution, 417
Dialysed iron, 617
Disinfectants, *v.* Oxygen.
sulphur.
iodine.
iodoform.
bromine.
chlorine.
hydrochloric acid.
nitric peroxide.
sulphurous acid.
arsenic.
calcium.
cuprum.
ferrum.
hydrargyrum.
manganese.
plumbum.
zinc.
Donovan's solution, 418
Douche, 164, 165
spinal, 165

Digitized by Google

E

Emplastrum Ferri, 616
hydrargyri, 671
plumbi, 721
iodidi, 721
Enema magnesiæ sulphatis, 696
Epsom salts, 694

F

Ferri Acetatis Tinctura, 556
et ammoniæ citras, 559
arsenias, 558
Bravais, 617
bromidum, 557, 617
carbonas saccharata, 557
carbonatis pilula, 616
emplastrum, 616
iodidum, 557
iodidi pilula, 616
syrupus, 616
et manganesii carbonas saccharata, 704
mistura aromatica, 615
composita, 616
oxidum magneticum, 554
perchloridi liquor, 616
fortior, 555
tinctura, 616
pernitratis liquor, 555
peroxidum humidum, 554
hydratum, 554
persulphatis liquor, 555
phosphas, 558
phosphatis syrupus, 616
et quiniæ citras, 559
redacti trochisci, 615
sulphas, 556
exsiccata, 556
granulata, 556
vinum, 615
Ferrum, 552
redactum, 553
tartaratum, 558
Filhos, caustique de, 516
Flowers of sulphur, 27
Fomentations, 170
Fowler's solution, 417

G

Glacial Acetic Acid, 231
Glauber's salt, 754
Glycerole of bismuth, 500
borax, 773
lead, 718
Gold, 476
Goulard extract, 721
Gregory's powder, 695
Grey powder, 671
Green iodide of mercury, 621
Griffith's mixture, 616

H

Hepar Sulphuris, 28, 726
Holsverck, lozenges of, 43
Hydrargyri ammoniati unguentum, 673
cyanidum, 624
emplastrum, 671
iodidum rubrum, 622
viride, 621
Hydrargyri iodidi rubri unguentum, 673
linimentum, 672
lotio flava, 673
nigra, 672
nitratis, liquor acidus, 623
unguentum, 673
oleas, 672
oxidum flavum, 622
rubrum, 622
oxidi rubri unguentum, 673
perchloridum, 620
perchloridi liquor, 672
pilula, 671
subchloridum, 619
subchloridi unguentum, 672
pilula composita, 672
sulphas, 623
sulphuretum, 623

Digitized by Google

Hydrargyri suppositoria, 672
unguentum, 671
compositum, 672
Hydrargyrum, 618
ammoniatum, 621
c. creta, 671
sulphuretum, 623
Hydrate of potash, 723
of soda, 753
Hydrated peroxide of iron, 554
Hydrobromic ether, 126
Hydrochloric acid, 246
Hydrochloric solution of arsenic, 417
Hydrocyanic acid, dilute, 260
Hydrogen, 20
peroxide of, 21
Hypochloride of sulphur, 28
Hypophosphite of iron, 617
lime, 530
soda, 756
Hyposulphite of soda, 302, 755

I

Inhalation of Ammonia, 334
chloride, 337
arsenical vapour, 471
bromine, 124
carbonic acid, 241
chlorine, 160
hydrocyanic acid, 276
iodine, 94
mercurial vapour, 655, 656
steam, 175
sulphurous acid, 309
Iodi, linimentum, 120
liquor, 120
tinctura, 120
unguentum, 120
vapor, 120
Iodide of ammonium, 77, 121
cadmium, 502
iron, 557
lead, 705
potassium, 76
sodium, 77
sulphur, 35
Iodine, 75
Iodoform, 77
collodion, 121
ointment, 121
Iron-alum, 341
Iron preparations, *v.* Ferrum.

K

Kalium, *v.* Potassium.
Kermes mineral, 356

L

Lac Bismuthi, 500
sulphuris, 27, 44
Lactate of iron, 503
Lacto-phosphate of lime, 510, 530
Lapis divinus, 543
Lead, *v.* Plumbum.
Ledoyen's solution, 716
Lehren's mercurial ointment, 671
Lightfoot's solution of iron, 617
Lime, *v.* Calx.
Linimentum ammoniæ, 340
calcis, 530
hydrargyri, 672
iodi, 120
potassii iodidi c. sapone, 751
Liquor ammoniæ acetatis, 324
citratis, 325
antimonii chloridi, 356
arsenicalis, 417
arsenici bromidi, 460
arsenici et hydrargyri hydriodatis, 418
arsenici hydrochloricus, 417
bismuthi and ammoniæ citratis, 488
calcis, 530
chloratæ, 508
saccharatus, 530
chlori, 155
ferri perchloridi, 616
fortior, 555
pernitratis, 555

Digitized by Google

Liquor ferri persulphatis, 555
hydrargyri nitratis acidus, 623
perchloridi, 672
iodi, 120
lithiæ effervescens, 682
magnesiæ carbonatis, 696
citratis, 696
plumbi subacetatis, 705
dilutus, 721
potassæ, 722
effervescens, 751
permanganatis, 752
sodæ, 753
arseniatis, 418
chloratæ, 756
effervescens, 773
zinci chloridi, 787
Litharge, 704
Lithia, 676
benzoas, 677
bromo-citras, 682
carbonas, 676
citras, 676
uras, 677
Lithiæ liquor effervescens, 682
Lithii bromidum, 126
Lithium, 675
Lotio hydrargyri flava, 673
nigra, 672
plumbi, 717
Löwe test, 487

M

Magnesia, 683
levis, 683
Magnesiæ boro-citras, 696
carbonas, 684
carbonatis liquor, 696
citratis liquor, 696
levis, 684
sulphas, 684, 696
sulphatis enema, 696
sulphis, 302
Magnesium, 683
Magnesii bromidum, 126
Magnesilyne, 696
Magnetic oxide of iron, 554
Manganesii oxidum nigrum, 697
sulphas, 697
Manganesium, 697
Manghan's iron, 616
Marcosita, 481
Marine acid, 246
Mentel's solution of alum, 350
Mercurial inunction, 673
hypodermic injection, 674
ointment, 671
pill, 671
plaster, 671
suppository, 672
vapour bath, 675
Mercury, *v.* Hydrargyrum.
hypodermic use of, 674
Milk of sulphur, 27, 44
Mineral baths and waters, 198
chameleon, 727
Mindererus spirit, 324
Mistura cretæ, 530
ferri aromatica, 615
composita, 616
Monsel's solution, 587, 617
Mustard pack, 173

N

Natrium, *v.* Sodium.
Nitrate of ammonia, 340
lead, 706, 716
mercury, 623
potash, 726
silver, 385
soda, 755
zinc, 785
Nitre, 726
Nitric acid, 277
Nitric oxide, 277
Nitric peroxide, 277, 279
Nitro-hydrochloric acid, 257
Nitrogen, 19

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O

Ointment, v. Unguentum.
Oleate of bismuth, 500
mercury, 672
zinc, 782
Oleum phosphoratum, 73
Oxalate of cerium, 531
Oxide of antimony, 356, 384
bismuth, 487
copper, 551
iron, 554
lead, 704
manganese, 697
mercury, 622
silver, 385
zinc, 776
Oxygen, 1
Oxymel, 236
Oyster shell, 28
Ozone, 1, 9

P

Pack, Dry, 173
mustard, 173
wet, 167
Patterson's powder, 499
Parrish's syrup, 617
Perchloride of iron, 555
of mercury, 620
Permanganate of potash, 727
Pernitrate of iron, 555
Peroxide of hydrogen, 21
iron, 554
Persulphate of iron, 555
Phosphate of ammonia, 325, 340
iron, 558
lime, 508
soda, 755
Phosphide of zinc, 46
Phosphoric acid, 285
Phosphori pilula, 74
tincturæ, 74
Phosphorus, 45
Pilula ferri carbonatis, 616
iodidi, 616
Pilula hydrargyri, 671
subchloridi comp., 672
phosphori, 74
plumbi c. opio, 721
Plumbi acetas, 704
acetatis unguentum, 721
carbonas, 705
carbonatis unguentum, 721
emplastrum, 721
iodidum, 705
iodidi emplastrum, 721
nitras, 706, 716
c. opio pilula, 721
oxidum, 704
subacetatis liquor, 705
dilutus, 721
unguentum compositum, 721
suppositoria composita, 721
Plumbum, 704
Potassa caustica, 723
sulphurata, 28, 726
Potassæ acetas, 724
bicarbonas, 724
bichromas, 728
carbonas, 723
chloras, 727
chloratis trochisci, 752
citras, 724
Potassæ liquor, 722
effervescens, 751
nitras, 726
permanganas, 727
permanganatis liquor, 752
sulphas, 302, 725
sulphuratæ lotio, 44
balneum, 44
unguentum, 752
tartras, 725
tartras acida, 725
Potassii bromidum, 125
iodidum, 76
iodidi c. sapone linimentum, 751
Potassium, 722
Poudre de Royer, 499
Wendt, 499
Precipitated chalk, 530

Digitized by Google

Precipitated sulphur, 27
Prussic acid, dilute, 260
Pulvis antimonialis, 384
cretæ aromaticus, 530
c. opio, 530
rhei comp., 695
Pyrophosphate of iron, 617

Q

Quevennes Iron, 553
Quicksilver, *v.* Hydrargyrum.

R

Reduced Iron, 553
Robiquet, preparations of, 617
Rochelle salt, 757

S

Saccharated Carbonate of Iron, 557
and manganese, 704
Saccharate of lime, 530
Sal ammoniac, 324
volatile, 340
"Sanitas," 21
Saltpetre, 726
Sapo duris, 752
Sapo mollis, 752
Sea-bathing, 194
Seidlitz powder, 321
Silver, 384
Soap, 752
Soda caustica, 753
tartarata, 757
Sodæ acetas, 755
arsenias, 418
biboras, 756
bicarbonas, 754
bicarbonatis trochisci, 773
carbonas, 753
exsiccata, 754
chloratæ cataplasma, 773
liquor, 756
citro-tartras effervescens, 757
hypophosphis, 756
hyposulphis, 302, 755
Sodæ liquor, 753
effervescens, 773
nitras, 755
phosphas, 755
sulphas, 754
sulphis, 302
thiosulphate, 755
valerianas, 773
Sodii chloridum, 757
bromidum, 126
iodidum, 77
Sodium, 752
Solution, *v.* Liquor.
Spanish white, 487
Spirits of ammonia, 346
of mindererus, 324
of salt, 246
Stanni pulvis, 775
chloridum, 775
Stannum, 774
Subacetate of copper, 535
lead, 705
Subcarbonate of bismuth, 488
Subchloride of mercury, 619
Subnitrate of bismuth, 487
Sugar of lead, 704
Sulphate of alumina, 341
cadmium, 502
copper, 535
iron, 556
magnesia, 684
manganese, 697
mercury, 623
potash, 302, 725
soda, 754
zinc, 777
Sulphide of ammonium, 325
calcium, 28
mercury, 623
Sulphites, alkaline, 302
Sulphur, 26
precipitatum, 27
sublimatum, 27
Sulphurated antimony, 355
potash, 28, 726
Sulphuric acid, 292
Sulphurous acid, 301

Digitized by Google

Sulphuris balneum co., 44
confectio, 43
hypochloridum, 28
iodidum, 35
lotio c. calce, 43
unguentum, 43
dilutum, 43
Suppositoria hydrargyri, 672
plumbi comp., 721
Syrupus ferri iodidi, 616
phosphatis, 616

T

Tannate of Bismuth, 500
Tartar emetic, 356
Tartarated antimony, 356
iron, 558
soda, 757
Tartrate of potash, 752
soda and potash, 757
Tin, 774
Tinctura cupri acetici, 551
ferri acetatis, 556
perchloridi, 616
iodi, 120
Tisy, preparations of, 617
Trochisci bismuthi, 499
potassæ chloratis, 752
sodæ bicarbonatis, 773

U

Unguentum Antimonii Tartarati, 384
bismuthi, 500
cadmii iodidi, 504
citrinum, 673
hydrargyri, 671
ammoniati, 673
comp., 672
iodidi rubri, 673
nitratis, 673
oxidi rubri, 673
flavi, 622
subchloridi, 672
iodi, 120
plumbi acetatis, 721
Unguentum plumbi carbonatis, 721
iodidi, 705
subacetatis comp., 721
potassæ sulphuratæ, 752
potassii iodidi, 76
sulphuris, 43
dilutum, 43
iodidi, 35
zinci, 787

V

Valerianate of Bismuth, 500
zinc, 778
Van den Corput's iron, 617
Vapor, *v.* Inhalation.
Verdigris, 535
Vienna paste, 738
Vinegar, 232
Vinum antimoniale, 384
ferri, 615
ferri citratis, 617
Vitriol, blue, 535
green, 556
white, 777

W

Water, 161
Waters, Aix-les-Bains, 218
Aix-la-Chapelle, 219
Alkaline, 199
Apollinaris, 203
Baden-Baden, 212
Bagnères de Luchon, 218
Barèges, 217
Bath, 225
Beulah Spa, 206
Bilin, 203
Bitter, 200
Bocklet, 228
Builth, 221
Buxton, 224
Carbonic Acid, 199
Carlsbad, 207
Cauterets, 217
Chalybeate, 201, 227
Cheltenham, 206

Digitized by Google

Waters, Classification of, 199
Common Salt, 200
Compound Soda, 200
Driburg, 228
Droitwich, 215
Earthy Mineral, 204
Eaux Bonnes, 216
Chaudes, 217
Ems, 204
Epsom, 206
Franzensbad, 209
Friedrichshall, 205
Gastein, 226
Gieshübel, 203
Hamburg, 210
Harrogate, 220, 229
Hunyadi Janos, 206
indifferent, 201
Inselbad, 224
Kilburn, 206
Kissingen, 211
Kniebis, 228
Königsworth, 228
Kreuth, 215
Kreuznach, 213
Leamington, 207
Leuk, 222
Lippspringe, 223
Lisdoonvarna, 222
Llandrindrod, 221
Llanwityd, 221
Luhatschowitz, 205
Marienbad, 209
Mineral, 198
Muriatic Soda, 199
Moffat, 221
Mont Dore, 203
Neuenahr, 202
Pfäffers, 225
Plombières, 225
Ponticosa, 217
Pullna, 206
Purton, 206
Pyrmont, 228
Ragatz, 225
Rehme, 214
Reichenhall, 213
St. Moritz, 228
Waters, St. Sauveur, 218
Saline, 199
Santa Catarina, 228
Salzbrunn, 203
Scarborough, 207
Schlangenbad, 227
Schwalbach, 228
Seidlitz, 206
Soden, 212
Spa. 229
Strathpeffer, 221
Streatham, 206
Sulphur, 201
Tarasp, 210
Teplitz, 225
Tunbridge Wells, 229
Vals, 202
Vichy, 202
Weilbach, 219
Weissenburg, 223
Weisbaden, 211
Wildbad, 226
Wildungen, 222
Woodhall, 216
Wet sheet, 163
towels, 163
White arsenic, 416
bismuth, 487
lead, 705
precipitate, 621
vitriol, 777
Wine of antimony, 384
iron, 615

Z

Zinci Acetas, 778
carbonas, 777
chloridum, 776
chloridi liquor, 787
pasta, 787
nitras, 787
oleis, 782
oxidum, 776
phosphidum, 46
sulphas, 777
unguentum, 787
valerianas, 778
Zincum, 776

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INDEX.

DISEASES.

A

ABORTION.
Iron, 575, 607

ABSCESS.
Ammonia, 332
Iodine, 101
Lime, 525
Phosphorus, 71
Potash, Caustic, 737, 784, 751
Sulphides, Sulphur, 37
v. Boil, Carbuncle.

ACIDITY, *v.* DYSPEPSIA.

ACID POISONING.
Alkalies, 742

ACNE.
Alkalies, 740
Ammonia, 332
Arsenic, 468
Calcium, 519
Iodine, 105
Mercury, 650
Nitro-hydrochloric Acid, 258
Phosphorus, 71
Sulphur, 34, 36
Water, 188

ADENITIS.
Ammonia, 332
Arsenic, 447
Bromides, 151

ADENITIS—*continued.*
Gold, 479
Iodine, 90, 111
Iodoform, 91
Iron, 615
Lead, 717, 719
Lime, 525
Mineral Waters, 210, 216
Mercury, 651, 667
Sulphur, 36

AGUE.
Antimony, 373
Arsenic, 443
Bromides, 152
Common Salt, 771
Copper, 550
Iodine, 110
Nitre, 744
Sulphurous Acid, 317
Water, 184

ALBUMINURIA.
Alkalies, 750
Alum, 350
Ammonia, 340
Arsenic, 460
Calcium, 529
Gold, 481
Iodides, 117
Iron, 610
Lead, 713, 719

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ALBUMINURIA—*continued.*
Oxygen, 17
Soda Salts, 769
Water, 187, 192

ALCOHOLISM.
Ammonia, 334
Arsenic, 471
Bromides, 148
Iron, 613
Zinc, 786
v. Delirium Tremens.

ALOPECIA.
Ammonia, 332
Arsenic, 468
Iodine, 106
Nitric Acid, 281

AMAUROSIS.
Phosphorus, 65

AMENORRHŒA.
Ammonia, 332
Arsenic, 463
Borax, 772
Barium, 485
Gold, 481
Iron, 603
Iodides, 120
Magnesia, 694
Sulphur, 43
Sitz Bath, 166

ANÆMIA.
Arsenic, 448
Calcium, 526
Chalybeate Waters, 201, 227
Iron, 600
Manganese, 701
Oxygen, 16
Phosphorus, 72
Sea-bathing, 197

ANEURISM.
Iodides, 117
Iron, 585
Lead, 720

ANGINA (SORE THROAT).
Alum, 347
Ammonia, 337
Carbonic Acid, 242
Chlorine, 158
Chlorate of Potash, 745
Hydrochloric Acid, 252
Iodides, 116
Iron, 597
Mercury, 656, 663
Sea-water, 196
Silver, 401, 402
Sulphur, 40
Waters, 216
Sulphuric Acid, 298
Sulphurous Acid, 303
Zinc, 783

ANGINA PECTORIS.
Arsenic, 454
Bromides, 145
Iron, 609
Phosphorus, 62
Silver, 413

APHONIA.
Ammonia, 337
Nitric Acid, 284
Silver, 401
Zinc, 783
v. Hoarseness.

APHTHÆ.
Alum, 347
Borax, 766
Calcium, 523
Chlorate of Potash, 739
Chlorine, 158
Copper, 543
Hydrochloric Acid, 252
Sulphurous Acid, 308

APOPLEXY.
Arsenic, 458
Bromides, 150
Ice, 189
Iodides, 110

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Apoplexy—*continued.*
Mercury, 659
Phosphorus, 61, 65
Silver, 412

Arthritis.
Alkaline Waters, 202
Arsenic, 450
Bromine, 125
Iodine, 110
Lead Lotion, 717
Mercury, 653
Potash, 741
Sulphur, 36, 41
Water, 193

Ascarides.
Arsenic, 450
Calcium, 520
Carbon, 26
Iron, 615
Mercury, 671
Salt, 767
Sulphur, 43
Tin, 775

Ascites.
Iodine, 97, 117
Iron, 609
Potash, 750
Mercury, 668
v. Albuminuria — Cirrhosis — Mitral Disease.

Asphyxia.
Chlorate of Potash, 746
Oxygen, 11
Peroxide of Hydrogen, 22
v. Asthma.

Asthma.
Alum, 354
Antimony, 383
Arsenic, 454
Bromides, 144
Carbonic Acid, 242
Copper, 546

Asthma—*continued.*
Hydrocyanic Acid, 276
Iodine, 115
Nitre, 745
Oxygen, 12
Silver, 413
Sulphur, 40
Sulphuric Acid, 308
Zinc, 786

Ataxia.
Arsenic, 458
Iodides, 110
Phosphorus, 66
Silver, 412
Sulphur, 41

B

Backache.
Water, 191

Balanitis.
Bismuth, 486
Calomel, 650
Iodoform, 103
Lead, 717
Silver, 398
Zinc, 783

Bedsore.
Iodoform, 102
Lead, 717
Silver, 403
Zinc, 782

Bites, Poisoned.
Ammonia, 332
Arsenic, 456
Potash, 751

Blepharitis.
Copper, 543
Iodine, 104
Lead, 717
Mercury, 656
Sulphur, 35
v. Conjunctivitis.

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Boil.
Arsenic, 403
Calcium, 519
Phosphorus, 71
Silver, 403
Sulphites, 314
Sulphur, 38

Bright's Disease.
v. Albuminuria.

Bromism.
Arsenic, 137
Coffee, 467

Bronchiectasis.
Chlorine, 160
Iodine, 104
Zinc, 785

Bronchitis.
Air, compressed, 13
Alkalies, 745
Alum, 354
Ammonia, 336, 337
Antimony, 375
Arsenic, 471
Calcium, 527
Carbonic Acid, 242
Copper, 546
Iodine, 115
Iron, 609
Lead, 719
Nitric Acid, 285
Nitro-hydrochloric Acid, 258
Oxygen, 13
Phosphorus, 69
Silver, 402
Sulphur, 40
Sulphurous Acid, 309
Water, 179
Zinc, 785

Bronchocele.
Barium, 485
Bromides, 147, 151

Bronchocele—*continued.*
Gold, 480
Iodine, 92, 119
Iron, 602
Lime Waters, 515
Mercury, 652
Phosphorus, 73

Bruises.
Sulphurous Acid, 306
Water, 177

Bubo.
Copper, 545
Iodoform, 103
Iron, 508, 615
Mercury, 651, 654
Nitric Acid, 279
Potash, Caustic, 737
Sulphur, 38
Water, 179

Burns.
Bicarbonate of Soda, 766
Calcium, 519
Iodine, 105
Lead, 717
Silver, 404
Sulphur, 35
Water, 178, 189

C

Calculus.
Calcium, 529
Hydrochloric Acid, 255
Lithia, 681
Magnesia, 689, 695
Mineral Waters, 200
Potassium, Salts of, 742
Nitro-hydrochloric Acid, 258
Phosphoric Acid, 290
Soda Salts, 769
Water, 178, 193

Cancer.
Acetic Acid, 234
Antimony, 371

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CANCER—*continued.*
Arsenic, 442
Calcium, 528
Citric Acid, 245
Copper, 544
Gold, 479
Iodoform, 93, 103
Iron, 581
Nitric Acid, 280
Potash, 737
Silver, 395
Zinc, 781
v. Epithelioma.

CANCER OF STOMACH.
Arsenic, 469
Bismuth, 496
Charcoal, 26
Hydrocyanic Acid, 274
Silver, 409

CANCRUM ORIS.
Calcium, 518
Mercury, 655
Nitric Acid, 279
Silver, 399
v. Aphthæ.

CARBUNCLE.
Calcium, 519
Silver, 403
Sulphur, 38
v. Abscess.

CARIES.
Calcium, 523
Common-salt Waters, 200
Copper, 545
Phosphoric Acid, 291
Phosphorus, 71
Potash, Caustic, 737
Sea-bathing, 198
Soda Salts, 766
Sulphuric Acid, 297
Zinc, 782

CATARRH.
Ammonia, 337

CATARRH—*continued.*
Bismuth, 494
Borax, 765
Bromine, 124
Chlorate of Potash, 745
Iodine, 104
Salt Water, 765.
Soda Waters, 200
Sulphurous Acid, 309
Water, 179
v. Coryza.

CELLULITIS.
Water, 178
v. Erysipelas.

CHANCRE.
Bromine, 124
Chlorine, 158
Iodoform, 103
Iron, 588
Lead, 719
Silver, 396
Water, 178
Zinc, 783
v. Syphilis.

CHILBLAINS.
Iodine, 102, 105
Sulphurous Acid, 307
v. Erythema.

CHLOASMA.
Borax, 765
Mercury, 648
Sulphurous Acid, 306

CHLOROSIS.
Arsenic, 448
Iron, 603
Manganese, 701
Oxygen, 16
v. Anæmia.

CHOLERA.
Arsenic, 472
Bismuth, 498
Bromides, 146

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CHOLERA—*continued.*
Copper, 548
Iron, 612
Lead, 721
Mercury, 670
Soda Salts, 771
Sulphur, 43
Sulphuric Acid, 299
Sulphurous Acid, 317
Water, 188
v. Diarrhœa.

CHOREA.
Antimony, 382
Arsenic, 455
Bromides, 142
Calcium, 526
Copper, 545
Iodine, 111
Iron, 613
Potash Salts, 750
Silver, 413
Tin, 775
Water, 190
Zinc, 786

CHYLURIA.
Iron, 611

CIRRHOSIS OF LIVER.
Acid Tartrate of Potash, 749
Nitro-hydrochloric Acid, 257
v. Ascites—Hepatic Disease.

CLIMACTERIC.
Ammonia, 338
Bromides, 143
Iron, 613
Zinc, 786

COLIC.
Ammonia, 339
Antimony, 380
Bromides, 144
Water, 188
v. Plumbism.

COLITIS.
v. Dysentery.

COLLAPSE.
Ammonia, 333, 334
v. Exhaustion.

CONDYLOMA.
Mercury, 654
Nitric Acid, 281
v. Syphilis.

CONGESTION, CEREBRAL.
Arsenic, 458
Bromides, 150
Water, 189
v. Apoplexy.

CONGESTION, HEPATIC.
Ammonium Chloride, 339
Chlorine, 160
Oxygen, 16
Sulphur, 42
Water, 187
v. Hepatic Disease.

CONGESTION, LARYNGEAL.
Silver, 401
Zinc, 783
v. Croup.

CONGESTION, PULMONARY.
Antimony, 376
Hydrogen, 22
Iodine, 94
Phosphorus, 68
v. Phthisis.

CONGESTION, SPINAL.
Arsenic, 459
Bromides, 151
Water, 191

CONJUNCTIVITIS.
Alum, 347
Antimony, 374
Arsenic, 447
Iodine, 104
Iron, 589
Lead, 717
Mercury, 656, 657

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CONJUNCTIVITIS—*continued.*
Nitric Acid, 283
Phosphoric Acid, 291
Silver, 400
Sulphur, 35, 37
Zinc, 783
v. Blepharitis.

CONSTIPATION.
Alum, 351
Antimony, 380
Magnesia, 692
Mercury, 668
Nitric Acid, 283
Potash Salts, 748
Saline Bitter Waters, 200
Soda Salts, 772
Sulphur, 42
Water, 192

CONSUMPTION.
v. Phthisis.

CONVULSIONS.
Antimony, 381
Bromides, 140
Water, 190
v. Epilepsy.

CORNS.
Nitric Acid, 281
Silver, 395
Sulphurous Acid, 307

CORYZA.
Arsenic, 470
Mercury, 662
Silver, 400
v. Catarrh.

COUGH.
Cerium, 533
Zinc, 786
v. Pertussis.

CROUP.
Alum, 353
Ammonia, 336
Antimony, 378
Bromides, 124

CROUP—*continued.*
Calcium, 517
Copper, 548
Iodine, 94, 116
Lithia, 682
Mercury, 662
Potash, Salts of, 745
Sulphur, 40
Water, 179

CYANOSIS.
Chlorate of Potash, 750
Hydrogen, 22
Oxygen, 12

CYSTITIS.
Alum, 349
Ammonia, 340
Bromides, 146
Carbonate of Soda, 766
Carbonic Acid, 240
Iron, 589
Nitric Acid, 282
Phosphoric Acid, 290
Silver, 397
Water, 179

CYSTS.
Bromides, 153
Iodine, 95, 98, 112
Silver, 405

D

DEBILITY.
Iron, 600, 613
Nitric Acid, 282
Phosphoric Acid, 289
Sea-bathing, 196
Silver, 413
Zinc, 786
v. Exhaustion.

DELIRIUM—DELIRIUM TREMENS.
Antimony, 382
Bromides, 148
Hydrocyanic Acid, 276
Water, 189
v. Alcoholism.

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DEMENTIA.
Phosphorus, 117

DENTITION.
Bromides, 141

DIABETES.
Alkalies, 749
Alum, 350
Ammonia, 340
Arsenic, 450
Calcium, 528
Carlsbad Waters, 208
Iron, 611
Bromide of, 611
Magnesia, 695
Oxygen, 16
Peroxide of Hydrogen, 22
Phosphoric Acid, 290
Soda Salts, 770

DIARRHŒA.
Acetic Acid, 236
Alum, 351
Arsenic, 471
Bicarbonate of Soda, 768
Bismuth, 497
Bromides, 145
Calcium, 522
Carbon, 25
Chlorate of Potash, 748
Copper, 547
Hydrochloric Acid, 290, 291
Iodine, 120
Iron, 612, 615
Lead, 721
Magnesia, 692, 693
Mercury, 669
Nitric Acid, 283
Phosphoric Acid, 292
Phosphorus, 69
Silver, 409
Sulphur, 43
Sulphuric Acid, 249
Sulphurous Acid, 317

DIARRHŒA—*continued.*
Water, 188
Zinc, 784

DIPHTHERIA.
Alum, 346
Bromides, 151
Bromine, 124
Calcium, 517
Compress, 187
Copper, 550
Hydrochloric Acid, 252
Ice, 187
Iodine, 94, 116
Iron, 593
Lithia, 682
Mercury, 662
Potassium, Salts of, 739, 744
Silver, 401
Sulphur, 38
Sulphurous Acid, 315

DIPSOMANIA.
Iron, 613
v. Alcoholism.

DROPSY.
Iron, 609
Potash Salts, 750
v. Ascites.

DYSENTERY.
Alum, 350
Bismuth, 498
Carbon, 25
Copper, 547
Iodine, 120
Iron, 612
Lead, 721
Magnesium, 693
Mercury, 670
Potash Salts, 748
Silver, 409
Soda Salts, 772
Sulphur, 43
Sulphurous Acid, 317
Water, 188

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DYSMENORRHŒA.
Ammonia, 338
Magnesia, 694
v. Amenorrhœa.

DYSPEPSIA.
Alkalies, 741
Ammonia, 339
Arsenic, 471
Bismuth, 495
Calcium, 521
Carbon, 25
Carbonic Acid, 243
Cerium, 533
Citric Acid, 245
Gold, 481
Hydrochloric Acid, 253
Hydrocyanic Acid, 274
Iron, 611
Magnesia, 691
Mercury, 668
Nitric Acid, 282
Nitro-hydrochloric Acid, 259
Peroxide of Hydrogen, 22
Sea-bathing, 196
Silver, 406
Soda Salts, 767
Turkish Bath, 187
Zinc, 784
v. Constipation.

DYSPHAGIA.
Bromides, 144

DYSPHONIA.
v. Hoarseness.

DYSPNŒA, CARDIAC.
v. Angina Pectoris.

DYSPNŒA, PULMONARY.
v. Congestion — Asthma — Emphysema.

E

ECTHYMA.
Calcium, 519
Iron, 590

ECTROPION—ENTROPION.
Sulphuric Acid, 298
v. Blepharitis.

ECZEMA.
Alum, 346
Antimony, 375
Arsenic, 465
Bismuth, 493
Bromides, 124
Calcium, 519
Hydrochloric Acid, 256
Iron, 590
Lead, 718
Mercury, 140, 649
Potassium, Salts of, 739
Silver, 403
Soda Salts, 765
Sulphur, 34
Water, 188
Zinc, 782

EFFUSION, PERICARDIAL, 98

EFFUSION, PLEURAL, 97
v. Pleurisy.

ELEPHANTIASIS.
Arsenic, 470

EMBOLISM.
Ammonia, 335
Soda Salts, 773

EMPHYSEMA.
Antimony, 383
Arsenic, 471
Copper, 546
Iron, 609
Oxygen, 12

EMPYEMA.
Chlorine, 158
Iodine, 97
Iron, 601, 615
Oxygen, 14

ENDOCARDITIS.
Mercury, 660

ENTERITIS.
Magnesia, 693

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ENTERITIS—*continued.*
Mercury, 661
v. Colic—Dysentery.

ENTERODYNIA.
Hydrocyanic Acid, 273
v. Colic.

ENURESIS.
Bromides, 144
Iron, 589

EPHELIDES.
Lime, 519
Mercury, 650

EPILEPSY.
Antimony, 382
Arsenic, 459
Barium, 486
Bromides, 135
Cerium, 533
Copper, 546
Gold, 486
Iodine, 111
Iron, 614
Lithia, 682
Phosphorus, 67
Silver, 411
Tin, 775
Water, 190
Zinc, 785

EPISTAXIS.
Alum, 349
Common Salt, 773
Hot Water, 176
Iron, 578
Phosphorus, 62
v. Hæmorrhage.

EPITHELIOMA.
Arsenic, 469
Bromide, 135
Calcium, 517
Mercury, 655
Potash, Caustic, 738
Chlorate, 738
v. Cancer.

ERYSIPELAS.
Arsenic, 469
Bromine, 123
Calcium, 519
Iodine, 105
Iron, 591
Lead, 717
Mercury, 651, 664
Silver, 403
Sulphurous Acid, 306, 315

ERYTHEMA.
Bismuth, 493
Calcium, 519
Iron, 590
Mercury, 650
Silver, 403
Zinc, 782

EXHAUSTION.
Ammonia, 334
Phosphorus, 61, 63, 64
v. Debility.

EXOPHTHALMOS.
v. Bronchocele.

EYE DISEASES.
Hydrocyanic Acid, 273
v. Conjunctivitis, &c.

F

FATTY DEGENERATION.
Phosphorus, 62

FAVUS.
Mercury, 648
Sulphur, 32
Sulphurous Acid, 306

FEVER.
Alkalies, 744
Ammonia, 335
Antimony, 372, 374
Hydrochloric Acid, 254
Nitric Acid, 283
Phosphoric Acid, 289
Sulphuric Acid, 299
Water, 180

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FEVER, PUERPERAL.
Mercury, 664
Sulphurous Acid, 314
Water, 183

FEVER, RHEUMATIC.
Alkalies, 743
Antimony, 373
Blanket Bath, 183
Iodides, 109
Iron, 398
Water, 183

FEVER, TYPHOID.
Alkalies, 744
Ammonia, 335
Antimony, 372
Carbon, 26
Copper, 547
Mercury, 663
Silver, 410
Sulphurous Acid, 315
Water, 184, 192

FEVER, TYPHUS.
Ammonia, 335

FIBROMA OF UTERUS.
Ammonia, 338
Bromides, 152
Calcium, 528
Iodine, 119
Iron, 581
Kreuznach Waters, 153
Mercury, 652

FISSURE OF ANUS.
Bromides, 135, 144
Iodoform, 102
Mercury, 654
Sulphur, 42

FISTULA.
Copper, 545
Iodine, 102
Zinc, 783

FLATULENCE.
v. Dyspepsia.

FRACTURE.
Calcium, 523
Phosphorus, 71
Silicate of Soda, 767
Sulphurous Acid, 307

FRAGILITAS, OSSIUM.
Calcium, 523

G

GANGRENE.
Alumina, 346
Arsenic, 469
Bromine, 123
Charcoal, 24
Chlorine, 160
Iron, 591
Oxygen, 10
Potash, 737
Sulphuric Acid, 308

GASTRALGIA—GASTRODYNIA.
Arsenic, 452
Cerium, 533
Manganese, 703
Prussic Acid, 273
Zinc, 784
v. Dyspepsia.

GASTRIC CATARRH.
Alum, 351
Arsenic, 472
Bismuth, 495
Silver, 406
v. Dyspepsia.

GASTRO-ENTERITIS.
v. Colic—Dysentery.

GINGIVITIS.
Alum, 346
Chlorate of Potash, 747
Iodine, 103

GLANDULAR ENLARGEMENT.
v. Adenitis—Struma.

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GOITRE.
v. Bronchocele.

GONORRHŒA.
Alum, 348
Antimony, 374
Bismuth, 495
Bromide, 146
Cadmium, 504
Copper, 544
Iodine, 104
Iron, 588
Lead, 719
Potash Salts, 739
Silver, 398
Zinc, 783

GOUT.
Carbolic Acid, 241
Hydrochloric Acid, 256
Iodine, 110
Lithia, 679
Magnesia, 695
Mineral Waters, 200
Soda, 766
Water, 171, 193

GOUT, RHEUMATIC.
Arsenic, 443
Iodides, 109, 110
Iron, 600
Sulphur, 41

GRAVEL.
Potash, 742
Water, 193
v. Gout.

GUMMA.
Iodine, 103
v. Syphilis.

H

HÆMATEMESIS—HÆMATURIA.
Alum, 350
Iron, 578, 579

HÆMOPTYSIS.
Alum, 350
Common Salt, 773
Iron, 578
Phosphoric Acid, 291

HÆMORRHAGE.
Acetic Acid, 235
Alum, 349, 350
Ammonia, 339
Iron, 576, 580, 582
Lead, 716, 718
Magnesia, 694
Manganese, 700
Phosphoric Acid, 291
Potash Salts, 749
Silver, 397
Sulphuric Acid, 299
Water, 176

HAIR, FALLING OFF OF.
v. Alopecia.

HAIR, SUPERFLUOUS.
Barium, 485
Lime, 516

HAY ASTHMA.
Arsenic, 470
Iodine, 116
Lime, 517
Sulphuric Acid, 309

HEADACHE.
Bromides, 142
Hydrochloric Acid, 254
Mercury, 652
Phosphorus, 65
Prussic Acid, 272
Silver, 413
Zinc, 787
v. Anæmia—Dyspepsia.

HEART DISEASE.
Arsenic, 460
Iron, 609
v. Angina Pectoris.

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HEMIANÆSTHESIA.
Gold, 481
HEMORRHOIDS.
v. Piles.
HEPATIC DISEASE.
Ammonia, 339
Manganese, 702
Mercury, 668
Nitric Acid, 282
Nitro-hydrochloric Acid, 257
Soda, 768
v. Cirrhosis—Congestion.
HERNIA.
Ice Water, 178
HERPES.
Arsenic, 469
Iron, 590
Mercury, 649
Phosphorus, 61
Zinc, 782
HOARSENESS.
Alum, 347
Ammonia, 337
Borax, 764
Potash, 747
HORDEOLUM.
Mercury, 657
HYDROCELE.
Copper, 545
Silver, 405
v. Cysts.
HYDROCEPHALUS.
Bromides, 151
Iodides, 112
Mercury, 659
v. Convulsion.
HYDROPHOBIA.
Oxygen, 17
Water, 191
HYDROTHORAX.
Iodine, 96
Iron, 609
v. Ascites.
HYPERIDROSIS.
Acetic Acid, 235
Tartaric Acid, 321
Zinc, 785
HYPERPYREXIA.
Water, 181
HYPOCHONDRIASIS.
Antimony, 382
Iron, 613
Phosphorus, 61
Sea-bathing, 196
Water, 190
v. Debility.
HYSTERIA.
Ammonia, 338
Bromides, 142
Copper, 546
Gold, 481
Iron, 613
Phosphorus, 66
Zinc, 786

I

ICHTHYOSIS.
Arsenic, 469
Copper, 544
Water, 188
IMPETIGO.
Iron, 590
Lime, 519
Nitric Acid, 284
Sulphurous Acid, 314
v. Eczema.
IMPOTENCE.
Phosphorus, 64
Water, 190
v. Debility.
INFLAMMATION.
Ammonia, 332
Antimony, 374
Iodine, 118
Lead, 717

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Inflammation—*continued.*
Mercury, 657
Water, 187

Ingrowing Nail.
Iron, 590
Potash, 739

Insomnia.
Antimony, 372
Bromides, 147
Water, 189

Intermittent Pulse.
Arsenic, 460

Intestinal Ulceration.
Copper, 544, 547
Phosphorus, 69
v. Dysentery—Typhoid Fever.

Irritation, Spinal.
Phosphorus, 64

J

Jaundice.
Magnesia, 693
Mineral Waters, 200
Silver, 409
Water, 187
v. Hepatic Disease.

L

Laryngeal Phthisis.
Silver, 401

Laryngismus.
Antimony, 380
Bromides, 143
Water, 179
v. Convulsion.

Leucocythæmia.
Arsenic, 448
Phosphorus, 72

Leucoma.
Soda Sulphate, 765

Leucorrhœa.
Alum, 348
Bismuth, 495
Bromides, 146
Cadmium, 504
Copper, 544
Iodine, 95
Iron, 588
Lime, 520
Lead, 719
Mineral Waters, 200
Potash Salts, 739
Silver, 398
Soda Salts, 766
Zinc, 783

Lichen.
Arsenic, 467
Iron, 590
Lead, 717
Mercury, 651
Prussic Acid, 272
Potash Salts, 741
Water, 188
v. Eczema.

Lithiasis.
Alkalies, 742
Magnesia, 695
v. Gravel.

Liver.
v. Hepatic Disease.

Locomotor Ataxy.
Phosphorus, 66
v. Ataxia.

Lumbago.
Antimony, 374
Iodides, 109
Sulphur, 26
v. Rheumatism.

Lumbricus.
v. Worms.

Lupus.
Acetate of Soda, 765
Acetic Acid, 234
Antimony, 371

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LUPUS—*continued.*
Arsenic, 442
Gold, 479
Iodine, 105, 112
Mercury, 655
Nitric Acid, 280
Phosphorus, 70
Potash, 737
Zinc, 781

LYMPHADENOMA.
Arsenic, 448
Phosphorus, 72

LYMPHANGITIS.
Mercury, 651
v. Adenitis.

M

MAMMARY GROWTHS.
Iodine, 93

MANIA.
Antimony, 381
Bromides, 149
Prussic Acid, 276
Water, 189, 190

MEASLES.
Ammonia, 336
Antimony, 373
Mercury, 663
Water, 187

MELANCHOLIA.
Antimony, 381
Phosphorus, 67
Water, 190
v. Hypochondriasis.

MENINGITIS.
Antimony, 370
Bromides, 151
Iodine, 112
Mercury, 658
Water, 189

MENORRHAGIA.
Alum, 350
Arsenic, 462
Bismuth, 497
Bromide, 146
Iodine, 95
Iron, 580
Lime, 528
Magnesia, 694
Nitric Acid, 280
Phosphoric Acid, 291
Phosphorus, 65
Silver, 408
Sulphuric Acid, 299

MERCURIALISM.
Alum, 346
Chlorate of Potash, 748
Hydrochloric Acid, 252
Iodine, 107
Sulphur, 41

MIGRAINE.
Ammonia, 337
v. Headache.

MITRAL DISEASE.
Arsenic, 460
Iron, 609
v. Heart Disease.

MOLLUSCUM CONTAGIOSUM.
Copper, 544
Silver, 396

N

NÆVUS.
Acetic Acid, 234
Antimony, 371
Iron, 586
Nitric Acid, 281
Potash, 737
Zinc, 782

NECROSIS.
Iron, 591
Potash, 737
v. Caries.

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NEPHRITIS.
Antimony, 380
Water, 187, 192
v. Albuminuria.

NEURALGIA.
Ammonia, 331, 337
Arsenic, 451
Bromides, 142
Iodine, 111
Iron, 613
Phosphorus, 59
Prussic Acid, 272
Silver, 405
Zinc, 787

O

OBESITY.
Acetic Acid, 236
Potash Salts, 749

ŒDEMA GLOTTIDIS.
Silver, 401
v. Angina.

ONYCHIA.
Iodine, 103
Iron, 596
Lead, 718
Lime, 516
Mercury, 654
Sulphurous Acid, 308

ORCHITIS.
Ammonia, 332
Antimony, 370, 374
Iodine, 92
Lead, 717
Mercury, 651
Silver, 404
Water, 178

OSMIDROSIS.
Charcoal, 25
Lime, 519

OSTEOMALACIA.
Lime, 523

OTORRHŒA.
Alum, 348
Iodoform, 104
Iron, 104
Lead, 717
Lime, 520
Nitric Acid, 283
Phosphorus, 70
Silver, 400
Zinc, 783

OXALURIA.
Hydrochloric Acid, 255
Nitro-hydrochloric Acid, 258
Phosphoric Acid, 290
v. Dyspepsia.

OVARITIS.
Antimony, 370
Bromides, 143
Iodine, 94, 110
Mercury, 652

OZÆNA.
Alum, 348
Bromine, 124
Iodine, 104
Mercury, 656
Potash Salts, 739
Silver, 400
Zinc, 783

P

PALPITATION.
Bromides, 145
Hydrocyanic Acid, 276
Sulphuric Acid, 300
v. Heart Disease.

PARALYSIS.
Carbonic Acid, 241
Iodine, 110
Phosphorus, 65
Silver, 412
Sulphur, 41
Water, 191
v. Ataxia.

PEMPHIGUS.
Arsenic, 466
Phosphorus, 71

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PERICARDITIS.
Iodine, 98
Mercury, 659
v. Rheumatism.

PERITONITIS.
Iodine, 94
Mercury, 661
Water, 187

PERTUSSIS.
Alkalies, 746
Alum, 353
Ammonia, 336
Bromides, 143
Copper, 546
Hydrocyanic Acid, 275
Nitric Acid, 284
Oxygen, 14
Peroxide of Hydrogen, 22
Potash, 746
Zinc, 786

PHAGEDÆNA.
Iron, 588
Nitric Acid, 279
Sulphurous Acid, 308
Water, 178
v. Ulceration.

PHOSPHATURIA.
Iron, 613
Nitric Acid, 282
Phosphoric Acid, 290

PHOSPHORUS POISONING.
Copper, 57, 550

PHTHEIRIASIS.
Arsenic, 441
Mercury, 647

PHTHISIS.
Antimony, 370
Arsenic, 445
Bromides, 147
Carbonic Acid, 242
Chlorine, 160

PHTHISIS—*continued.*
Hydrocyanic Acid, 274
Iodine, 93, 114
Iron, 608
Lead, 719
Lime Salts, 526
Nitrogen, 20
Oxygen, 14
Peroxide of Hydrogen, 22
Phosphoric Acid, 290
Phosphorus, 69
Potash Chlorate, 746
Soda Salts, 771
Sulphur, 40
Sulphuric Acid, 300
Sulphurous Acid, 309
Water, 180
Waters, Mineral, 201
Zinc, 785

PILES.
Arsenic, 463
Bismuth, 494
Bromide, 135
Iodine, 102
Iron, 587
Lead, 719
Mercury, 668
Nitric Acid, 280
Sulphur, 42
Water, 179

PITYRIASIS CAPITIS.
Iodine, 106
Mercury, 649
Potash, 740
Soda, 765

PITYRIASIS RUBRA.
Iron, 590
Water, 188

PITYRIASIS VERSICOLOR.
v. Chloasma.

PLEURISY.
Ammonia, 336
Iodine, 93, 97

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PLEURISY—*continued.*
Iron, 609
Mercury, 652, 660
Oxygen, 14
Phosphorus, 69

PLUMBISM.
Alum, 352
Iodine, 107
Magnesia, 691
Sulphur, 42
Sulphuric Acid, 300

PNEUMONIA.
Ammonia, 336
Antimony, 376
Hydrochloric Acid, 256
Iodine, 114
Lead, 720
Mercury, 661
Phosphorus, 68
Sulphides, 38

POLYPUS NASI.
Alum, 348
Iron, 591

PREGNANCY.
Iron, 607

PROLAPSUS.
Alum, 348
Nitric Acid, 281
v. Leucorrhœa.

PROSTATITIS.
Ammonia, 340
Antimony, 374
Iodine, 93
v. Adenitis.

PRURIGO—PRURITUS.
Ammonia, 332
Hydrocyanic Acid, 272
Iodine, 106
Iron, 590
Lime Salts, 519
Mercury, 651
Nitric Acid, 281

PRURIGO—PRURITUS—*continued.*
Soda Salts, 765
Sulphur, 34
Sulphuric Acid, 298
Sulphurous Acid, 306
Water, 188

PSORIASIS.
Acetic Acid, 235
Arsenic, 464
Iodine, 106
Mercury, 650
Nitric Acid, 284
Phosphorus, 70
Potash Salts, 741
Sulphur, 34
Water, 188

PURPURA.
Iron, 580
Potash Salts, 749

PYÆMIA.
Ammonia, 333
Potash Salts, 750
Sulphurous Acid, 313

PYROSIS.
Bismuth, 496
Manganese, 703
Sulphurous Acid, 318
v. Dyspepsia.

R

RACHITIS.
Iodine, 111
Iron, 615
Lime, 524
Nitro-hydrochloric Acid, 258
Phosphoric Acid, 290, 292
Phosphorus, 71

RELAXED THROAT.
Silver, 401
Sulphurous Acid, 308
v. Angina.

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RHEUMATISM.
Ammonia, 331
Arsenic, 450
Baths, 172, 183
Bromides, 151
Citric Acid, 245
Iodine, 109
Iron, 598
Lithia, 682
Mineral Waters, 201
Nitro-hydrochloric Acid, 259
Potash Salts, 741
Soda Salts, 766
Sulphur, 36, 41
Zinc, 787
v. Rheumatic Fever.

RUPIA.
Iron, 590
Nitric Acid, 284
v. Syphilis.

S

SATYRIASIS.
Bromides, 150
Phosphorus, 64

SCABIES.
Arsenic, 441
Lime Salts, 519
Manganese, 701
Potash Salts, 740
Sulphur, 32
Sulphuric Acid, 298

SCARLATINA.
Acetic Acid, 235
Alkalies, 744
Ammonia, 335
Antimony, 373
Bromides, 169
Hydrochloric Acid, 255
Iron, 597
Mercury, 663
Potash Chlorate, 744
Sulphur, 40
Water, 185

SCIATICA.
Arsenic, 452
Copper, 544
Iodides, 111
Nitro-hydrochloric Acid, 259
Silver, 405
Sulphur, 36
v. Rheumatism.

SCROFULA.
Arsenic, 447
Barium, 485
Bromides, 124, 125
Cadmium, 504
Gold, 480
Iodine, 90, 111
Iron, 615
Lime Salts, 525
Mercury, 667
Phosphoric Acid, 290
Potash Chlorate, 747
Sea-bathing, 196
Soda Salts, 764, 771
Sulphur, 36.

SCURVY.
Citric Acid, 245
Iron, 580
Phosphoric Acid, 291
Potash Salts, 749

SEPTICÆMIA.
Ammonia, 333—335
Potash, 750
Sulphurous Acid, 313

SHOCK.
Ammonia, 333
v. Collapse—Exhaustion.

SMALL-POX.
Antimony, 373
Hydrochloric Acid, 255
Iron, 597
Lime Salts, 520
Mercury, 651, 663
Sulphurous Acid, 314
Water, 187

SNAKE BITE.
v. Bites.

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Sore Nipple.
Borax, 765
Lead, 718
Silver, 404
Sulphurous Acid, 307

Sore Throat.
v. Angina.

Spermatorrhœa.
Acetic Acid, 235
Bromides, 146
Iron, 589
Phosphorus, 64
Silver, 398

Spina Bifida.
Iodine, 95

Splenic Enlargement.
Bromides, 151
Iodides, 118
Lead, 719
Mercury, 653
v. Ague.

Sprains.
Sea-bathing, 196
Sulphurous Acid, 307

Stings.
Ammonia, 332
v. Bites.

Stomatitis.
Alum, 346
Potash Chlorate, 747
v. Aphthæ.

Stricture, Urethral.
Potash, 738
Water, 178

Strychnia Poisoning.
Bromides, 141
Iodine, 90
Oxygen, 17

Sunstroke.
Water, 189
v. Congestion, Cerebral.

Suppuration.
Potash Salts, 747
Sulphur, 37
v. Abscess.

Sycosis.
Arsenic, 469
Iodine, 105
Mercury, 650
Sulphur, 33

Synovitis.
Iodine, 96
Lead, 719
Mercury, 653
Silver, 404
v. Arthritis.

Syphilis.
Copper, 551
Gold, 480
Hydrochloric Acid, 256
Iodine, 108
Iron, 614
Mercury, 654, 664
Nitric Acid, 283
Nitro-hydrochloric Acid, 258
Potash Salts, 738, 751
Sulphur, 38
Sulphurous Acid, 318
Water, 193

T

Tapeworm.
Copper, 547
v. Worms.

Tenesmus.
Bromides, 144

Tetanus.
Barium, 486
Bromides, 141
Gold, 486
Oxygen, 17
Potash Salts, 750
Water, 190

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THROMBOSIS.
Ammonia, 335

TINEA TARSI.
Copper, 543
v. Blepharitis.

TINEA TONSURANS.
Acetic Acid, 235
Iodine, 106
Iron, 590
Lime, 519
Manganese, 701
Mercury, 648
Potash Salts, 740
Prussic Acid, 273
Sulphuric Acid, 298
Sulphurous Acid, 306

TINEA VERSICOLOR.
v. Chloasma.

TONSILS, ENLARGED.
Bromides, 152
Iodine, 91
Iron, 615
Lime, 516

TONSILLITIS.
Alum, 347
Antimony, 374
Mercury, 662
Silver, 401
v. Angina.

TOOTHACHE.
Alum, 347
Soda, 766

TREMOR.
Arsenic, 458
Phosphorus, 66
Silver, 413
Zinc, 787

TUMOUR, FIBROID.
v. Fibroma.

TUMOUR, OVARIAN.
v. Cysts.

U

ULCERATION.
Bromides, 134
Copper, 544
Iodine, 102
Iron, 591
Lead, 717
Lime, 518
Mercury, 654
Nitric Acid, 281
Oxygen, 10
Potash, 737
Silver, 399
Sulphurous Acid, 308
Water, 177

URÆMIA.
Water, 190
v. Albuminuria—Convulsion.

URETHRITIS.
Bromides, 146
Chlorine, 158
v. Gonorrhœa.

URTICARIA.
Arsenic, 468
Bromides, 147
Potash Salts, 741
Prussic Acid, 272
v. Pruritus.

UTERINE CONGESTION, &c.
Arsenic, 462
Bromides, 143
Gold, 481
Iodine, 94, 119
Lime, 528
Nitric Acid, 280
Potash, 738
Silver, 399, 408
v. Cancer—Menorrhagia, &c.

V

VAGUS, IRRITATION OF.
Bromides, 145

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VARICOCELE.
Water, 179
VARIX.
Iron, 586
Potash, 737
VERTIGO.
Bromides, 142
Prussic Acid, 276
v. Dyspepsia.
VOMITING.
Alkalies, 742
Arsenic, 471
Bromides, 145
Carbonic Acid, 243
Cerium, 532
Iodine, 120
Lime, 521
Mercury, 669
Prussic Acid, 274
Soda Salts, 768
Sulphurous Acid, 318
VULVITIS.
Alum, 348
Lead, 717
Silver, 398

W

WARTS.
Copper, 544
Magnesia, 695
Nitric Acid, 281
Potash, 738
Silver, 395
Zinc, 782
WHITLOW.
v. Onychia.
WORMS.
Copper, 547
Iron, 615
Mercury, 671
Tin, 775
v. Ascarides.
WOUNDS.
Carbonic Acid, 240
Chlorine, 765
Lead, 717, 718
Potash Salts, 739
Silver, 395
Sulphurous Acid, 307
Water, 177
Zinc, 782
v. Ulceration.

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Acton's Reproductive Organs, 14
Adams (W.) on Clubfoot, 11
——— Contraction of the Fingers, 11
Allan on Fever Nursing, 7
Allingham on Diseases of the Rectum, 13
Anatomical Remembrancer, 4
Anderson (McC.) on Eczema, 13
Aveling's Influence of Posture on Women, 6
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Charteris' Practice of Medicine, 8
Clark's Outlines of Surgery, 10
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Cormack's Clinical Studies, 8
Coulson on Stone in the Bladder, 14
——— on Syphilis, 14
——— on Diseases of the Bladder, 14
Cripps' Cancer of the Rectum, 13
Cullingworth's Nurse's Companion, 7
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——— on Diseases of Women, 5
Dunglison's Medical Dictionary, 14
Ellis's Manual for Mothers, 6
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Fayrer's Observations in India, 7
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——— Stomach, 9
——— Pneumogastric Nerve, 9
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Hardwicke's Medical Education, 14
Harris on Lithotomy, 14
Harrison's Surgical Disorders of the Urinary Organs, 14
——— Prevention of Stricture, 14
Heath's Injuries and Diseases of the Jaws, 10
——— Minor Surgery and Bandaging, 10
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——— Practical Anatomy, 3
——— Surgical Diagnosis, 10
Hemming on the Laryngoscope, 12
Higgens' Ophthalmic Out-patient Practice, 11
Hillis' Leprosy in British Guiana, 13
Hogg's Indian Notes, 7
Holden's Dissections, 3
——— Human Osteology, 3
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Lee (H.) on Syphilis, 14
Leared on Imperfect Digestion, 10
Liebreich's Atlas of Ophthalmoscopy, 11
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——— on Surgery of the Face, 12
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Moore's Family Medicine for India, 7

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Osborn on Diseases of the Testis, 13
——— on Hydrocele, 13
Parkes' Practical Hygiene, 5
Pavy on Diabetes, 10
——— on Food and Dietetics, 10
Peacock's Diseases of the Heart, 9
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——— Diseases of the Urinary Organs, 13
——— Diseases of the Prostate, 13
——— Lithotomy and Lithotrity, 13
Thompson's (Dr. H.) Clinical Lectures, 8
Thorowgood on Asthma, 8
——— on Materia Medica, 7
Thudichum's Pathology of the Urine, 14
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——— Map of Motor Points, 10
Tilt's Change of Life, 6
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——— (J. & C. S.) Dental Surgery, 12
Van Buren on the Genito-Urinary Organs, 14
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——— Practical Therapeutics, 7
Warner's Guide to Medical Case-Taking, 8
Waters' (A. T. H.) Diseases of the Chest, 8
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Wells (Spencer) on Ovarian and Uterine Tumours, 8
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